# The Dissolution of Metals used in the Super Alloy CMSX-4 by means of Aqua Regia, with the focus of recovering Rhenium by means of Molecular Imprinted Polymers

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This is to certify that I am responsible for the work submitted in this thesis, that the original work is my own, except as specified in the acknowledgements and in references, and that neither the thesis nor the original work contained therein has been previously submitted to any institution for a degree.

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**Abstract**

Aqua regia, which is an acid solution of hydrochloric acid and nitric acid, was used at three different strengths, over a period of seven days, to see how effective it was at dissolving the individual metals that are used in the super alloy CMSX-4. Tantalum, Hafnium and Titanium could all withstand the corrosive effects and did not dissolve. The strongest strength of aqua regia (not diluted) managed to partially dissolve the other metals, with Molybdenum being fully dissolved. The two diluted solutions of aqua regia were not as affective, however rhenium managed to be fully dissolved

Super alloys, which are used in industries such as the aviation and energy sectors, are a combination of specific metals which exhibit special characteristics. When the metals are alloyed together, they produce an alloy that can withstand extreme temperatures (over +1000°C) and workloads over an extended period of time, without the integrity of the alloy being affected. As technologies change different generations of super alloys have been developed. A second generation super alloy, CMSX-4, contains 3% rhenium and rhenium being an extremely rare element, is an expensive metal to use (around £2500 per kg).

Molecular imprinted polymers are a new separation technique that has become increasingly popular due to their benefits of, ease of creation; low cost and extremely specific separation abilities. The specific separation is achieved during the polymerisation process, by using a template, identical in chemical and structure to the analyte of interest, allowing for separation of the analyte of interest, even in the presence of similar structural and chemical compounds.

Five molecular imprinted polymers were made, each with different concentrations of rhenium template. They were tested to not only see if they could successfully trap rhenium, but to also investigate if the maximum loading of the molecular imprinted polymer would increase as the concentration of the template increased. Throughout the research, the molecular imprinted polymers were analysed by X-Ray fluorescence to determine the presence of trapped rhenium. The solutions that were eluted through the polymers were analysed by Atomic Absorption Spectroscopy to identify how much rhenium was not being trapped by the molecular imprinted polymer during the analyte loading stage and how much rhenium was being removed during the analyte removal stage.

The research also investigated to see if a re-useable polymer was produced. The results indicated that not only could the molecular imprinted polymer trap rhenium; it could also be removed and then re-used again at least four times, without the maximum loading capacity diminishing. The results also confirmed that it was possible to trap 75mg of rhenium using 1g of polymer. Doubling the template from 60mg to 120mg did not increase the loading capacity, identifying that there was a limit to the maximum loading of the polymer, even with increased concentration of template.

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<u>**Content List**</u>

## List of tables and figures

## List of Abbreviations

| Abbreviation | Meaning | Abbreviation | Meaning |
|---|---|---|---|
| **AA** | Peak Area | **AA - BG** | Peak Area - Background |
| **A:AR** | Aqua regia | **AAS** | Atomic Absorption Spectroscopy |
| **AB** | Aqua regia :Time | **ACBN** | 1,1' azobis(cycloheaxanecarbonitirile) |
| **AcTSn** | Acetaldehyde thiosemicarbazone | **AIBN** | 2,2-azobisisobutyronitrile |
| **Al** | Aluminium | **$AlNO_3$** | Aluminium nitrate |
| **AR** | Aqua regia | **A.R** | After rinse |
| **As** | Arsenic | **B** | Boron |
| **B:** | Time | **BB** | Time:time |
| **Bi** | Bismuth | **BlnkCorr** | Blank correction |
| **B.R.** | Before rinse | **C** | Carbon |
| **$CH_2$** | Methylene | **Co** | Cobalt |
| **Conc.** | Concentration | **cont.** | Continued |
| **$CoNO_3$** | Cobalt nitrate | **Cr** | Chromium |
| **$CrNO_3$** | Chromium nitrate | **CPI** | Chemical process industry |
| **Cu** | Copper | **EGDMA** | Ethyleneglycoldimethacrylate |
| **fcc** | Face-centered-cubic | **Fe** | Iron |
| **FT-IR** | Fourier Transform Infrared Spectroscopy | **H** | Hydrogen |
| **HCl** | Hydrochloric Acid | **HCL** | Hallow cathode lamp |
| **hcp** | hexagonal close-packed | **HEMA** | 2-hydroxy ethyl methacrylate |

| | | | |
|---|---|---|---|
| **Hf** | Hafnium | **HF** | Hydrofluoric Acid |
| **$HNO_3$** | Nitric Acid | **ICP-MS** | Inductively Coupled Plasma - Mass Spectroscopy |
| **IIP** | Ion-imprinted polymers | **KRe04** | Potassium perrhenate |
| **ktpa** | Kilo ton per annum | **MAH** | Meth-acryloylamidohistidine |
| **Mg** | Magnesium | **MIP** | Molecular imprinted polymer |
| **Mn** | Manganese | **Mo** | Molybdenum |
| **M** | Molar | **$MoS_2$** | Molybdenite |
| **N** | Nitrogen | **Nb** | Niobium |
| **NH4ReO4** | Ammonium perrhenate | **Ni** | Nickel |
| **$NiNO_3$** | Nickel nitrate | **$NO_3$** | Nitrate |
| **O** | Oxygen | **Pa** | Per annum |
| **Pd** | Palladium | **PIN** | Positive-intrinsic-negative |
| **ppb** | Parts per billion | **Ppm** | Parts per million |
| **R** | Replica | **Rb** | Rubidium |
| **Re** | Rhenium | **RSD%** | Relative standard deviation % |
| **Ru** | Ruthenium | **S.A.** | Super alloy |
| **Sb** | Antimony | **SD** | Standard deviation |
| **Se** | Selenium | **SEM** | Scanning electron microscope |
| **SEM-EDX** | Scanning electron microscope - Energy Dispersive X-ray | **Si** | Silicon |
| **Sn** | Tin | **SPE** | Solid Phase Extraction |
| **Ta** | Tantalum | **Tc** | Technetium |
| **Ti** | Titanium | **TiO2** | Titanium oxide |

| | | | |
|---|---|---|---|
| **TSd** | thiosemicarbazide (N-aminootheiourea) | **T1** | Test 1 |
| **T2** | Test 2 | **T3** | Test 3 |
| **T4** | Test 4 | **T5** | Test 5 |
| **T6** | Test 6 | **U.S.** | Ultra Sonic |
| **V** | Vanadium | **W** | Tungsten |
| **wt. %** | % weight | **W1** | Wash 1 |
| **W2** | Wash 2 | **W3** | Wash 3 |
| **XRF** | X-ray fluorescence | **Y** | Gamma |
| **y'** | gamma prime | **Zn** | Zinc |
| **Zr** | Zirconium | **4VP** | 4- Vinyl pyridine |

# 1. Introduction

## 1.1 The area's being covered in this study

Industries such as the aviation and energy sectors have machinery that is pushed to the extreme, having to withstand extensive stresses and strains and extremely high temperatures. Normal steel would not be able to withstand these extremes and so the development of specific metals, combined together to produce a durable metal was introduced, known as super alloys. The word alloy means more than one metal is combined together. The different metals within super alloys all contribute to the end result which is a metal that can withstand extremely high temperatures (1000°C +) and has remarkable durability and is extremely resistant to degradation.

Some of the metals used in the making of super alloys are extremely rare and expensive. Rhenium is used in later generations of super alloys and is the most expensive element in single crystal super alloys (Li *et al*, 2000); it plays an important role in improving the effectiveness of super alloys. Super alloy CMSX-4 is a second generation alloy and is the metal being investigated in this study.

Over recent years, scrap super alloys have increased due to machines containing super alloys coming to the end of their life cycle. For this reason there is an accumulation of rare and expensive metals, such as rhenium going to waste. Despite manufacturers having methods on melting down the old super alloys and re-shaping them into new alloys, waste is produced. This waste has the potential to contain thousands of pounds of metals that currently get thrown away. If this project could find a way in separating the metals from waste products and recover them so that the metals could be reused in industry it would have a positive effect, not only on the environment but also on the cost of industrial waste management. This project focuses on trying to find a way to separate rhenium from super alloys as this is the rarest and most expensive metal used.

Molecular imprinted polymers are a relatively new separation technique that has found use in many disciplines (chromatographic separations, catalysis, sensors, materials) and, consequently, are attracting attention in the scientific community (García-Calzón and Díaz-García, 2007). Molecular imprinted polymers are very analyte specific as, when they are produced; a template of the analyte of interest is used, making the molecular imprinted polymer specific to that analyte. It works in a similar way to natural biological processes such as the enzyme and substrate lock and key complex where only a specific substrate can interact with a specific enzyme with the ability to not interact with substrates that are not compatible.

Molecular imprinted polymers have been used to extract metals and literature has shown that metals such as nickel and cobalt have been separated using this method. Bhaskarapillai *et al* (2009) looked into the selectivity of a cobalt imprinting polymer and found that the synthesised molecular imprinted polymers pick up cobalt ions even when present in small concentration and from complexing media as well.

There is however, no literature on the separation of rhenium using molecular imprinted polymers. Therefore, researching into creating an effective molecular imprinted polymer to separate rhenium from super alloys is an area of great interest.

Aqua regia, which is a combination of Hydrochloric Acid (HCl) and Nitric Acid ($HNO_3$) used in a ratio of 3:1, is an extremely strong acid combination that can dissolve most metals, including platinum and gold. The research will look to see how many of the individual metals used in the super alloy CMSX-4 can be dissolved in aqua regia to try and get a better understanding of how the individual metals react and so help to find an effective way of breaking down super alloys using aqua regia.

Using acids in large quantities becomes expensive, hazardous and creates a potential disposal issue after use. An area of interest in this study is to see if using diluted aqua regia (still with an HCl, $HNO_3$ ratio of 3:1) would work as effectively as pure aqua regia. If positive results are obtained then this could have a positive effect on the cost and environment in regards to the use of aqua regia.

The main area's that this research is focused on is as follows:

- To see if dilute aqua regia works as effectively as pure aqua regia in the dissolution of metals used in the super alloy CMSX-4.
- To see if it is possible to make a molecular imprinted polymer that can trap and recover rhenium and if so, see if it can be both re-useable and reproducible.
- To see if a successful rhenium molecular imprinted polymer would be cost effective and profitable if used on an industrial scale.

## 1.2. Literature Review

### 1.2.1. Super alloys

1.2.1.1. What are super alloys?

Super alloys are metallic compounds that exhibit special properties which enable them to withstand extreme temperatures without their complex structure being compromised. Choudhury *et al* (1998) states that super alloys are heat-resistant alloys of nickel, nickel-iron, or cobalt that exhibit a combination of mechanical strength and resistance to surface degradation generally unmatched by other metallic compounds. Nickel, Nickel-Iron and cobalt are the three main metals used in producing super alloys with Nickel - based super alloys being among the most widely used high-temperature structural materials because they have an excellent balance of physical and mechanical properties (Yoon *et al*, 2009). Nie *et al* (2009) expands on what Yoon *et al* (2009) has said by explaining that Nickel-based super-alloys are widely used in many industrial machines' components under extreme working conditions, since they have high strength, good creep and fatigue properties.
Creep is where a material changes its original shape permanently due to stresses enforced on the material. Creep fatigue is the main damage form of engine parts operating under both cyclic mechanical and thermal loading conditions (Zhang *et al,* 2011); therefore super alloys having good creep properties means that they can withstand a large amount of stresses without their shape deforming.
Mechanical fatigue happens when cracking occurs on the alloy which can result in failure of the appliance. Gao *et al* (2005) suggests that a critical property of these alloys is their resistance to fatigue-crack propagation, particularly at service temperatures. Gao *et al* (2005) goes on to explain that there are two types of fatigue: low-cycle fatigue, which results from relatively large cycles associated with the stopping and starting of the turbine; and high-cycle fatigue, associated with vibrational loading during service.

Due to super alloys having these remarkable properties they have been used in a wide variety of applications where other metallic compounds would fail. Their main use is in industry, particularly in aerospace technology. Yoon *et al* (2009) say that super alloys have been used in the most demanding applications, including turbine blades for jet engines and land-based gas turbines since the mid twentieth century. Choudhury *et al* (1998) supports

Yoon *et al* (2009) and further describes what machinery parts use super alloys in their different application, which is as follows: (i) aircraft gas turbines, e.g. disks, combustion chambers, bolts, castings, shaft exhaust systems, blades, vanes, etc.; (ii) steam turbine power plants, e.g. bolts, blades, stack gas reheaters; (iii) reciprocating engines, e.g. turbocharger, exhaust valves, hot plugs etc.

#### 1.2.1.2. History of super alloys

The core technology for increasing the generative efficiency is to improve the performance of steam turbines. In order to improve the performance of steam turbines, since the temperature of the operating steam should be elevated greatly, it is very important to develop a high temperature material that is able to enable both durability and reliability under extreme environments (Park *et al*, 2011).

Due to the need for having a material that can withstand extreme environments super alloys were developed and have been around for a long time and have gone through a number of generations, improving as the knowledge, technology and demand has increased. First generations and second generation single crystal alloys have been widely used for advanced commercial and military aero engines since the 1980's (Li *et al*, 2000). Walston *et al* (1996) supports this statement and says that since their development in the late 1980's, second generations, single crystal super alloys have attained success in both commercial and military aircraft engines. The term single crystal refers to the fact that single crystal super alloys are completely made up of a continuous crystal lattice (atoms arranged in a particular cube format) which is unbroken and so has no grain boundaries.

Super alloys have designated names which can help distinguish between different generations. For example, René N4, René N5 and René N6 are first, second and third generation super alloys respectively. Walston *et al* (1996) explains that René N6 is approximately 30°C stronger than the second generation single crystal, René N5. This is supported by Li *et al* (2000) who states that second generation single crystal alloys provide an approximate 30°C improvement of creep strength relative to the first generation, while the third generation exhibit about 60°C improvement of creep strength in comparison to the first. This shows that newer generations of super alloys have increased strength by about 30°C compared to the generation before. Another distinction between the different generations is the difference in their chemical composition with the main change being the presence of rhenium in the later generations of super alloys. Li *et al* (2000) states, that the main distinction of the chemical compositions of the first, second and third generation single crystal super alloys is rhenium-free, 3 wt. % Rhenium and 6 wt % Rhenium, respectively.

Zeng *et al* (2009) agrees with Li *et al* (2000) and says that second and third generation single crystal Nickel-based super alloys typically contain 3-6wt. % Rhenium. The increase of Rhenium is to enhance the creep performance and fatigue strength of these super alloys (Zeng *et al,* 2009).

Table 1 shows the differences in the composition, in weight percentage (wt. %) of first to third generation super alloys René N4, René N5 and René N6.

Table 1 - Nominal composition of three generations of super alloys (wt. %)

| Element | Cr | Co | Mo | W | Ta | Re | V | Nb | Al | Ti | Hf | B | Ni | Density |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alloy | First Generation | | | | | | | | | | | | | Kg/cm$^2$ |
| René N4 | 9 | 8 | 2 | 6 | 4 | - | - | 0.5 | 3.7 | 4.2 | - | - | Bal. | 8.56 |
| | Second Generation | | | | | | | | | | | | | |
| René N5 | 7 | 7.5 | 1.5 | 5 | 7 | 3 | - | - | 6.2 | - | 0.15 | 0.004 | Bal. | 8.63 |
| | Third Generation | | | | | | | | | | | | | |
| René N6 | 4.2 | 12.5 | 1.4 | 6 | 7.2 | 5.4 | - | - | 5.75 | - | 0.15 | - | Bal | 8.98 |

(Figures obtained from Li *et al*, 2000)

The elements in table 1 are: Cr = Chromium; Co = Cobalt; Mo = Molybdenum; W = Tungsten; Ta = Tantalum; Re = Rhenium; V = Vanadium; Nb = Niobium; Al = Aluminium; Ti = Titanium; Hf = Hafnium; B = Boron and Ni = Nickel.

Despite super alloys having increased strength at high temperatures, they can still have problems at elevated temperatures. Zhang *et al* (2011) says that super alloys have been developed for high-temperature applications, but they are not able to meet both the high-temperature strength and the high-temperature corrosion resistance simultaneously, so protective coatings on super-alloys are used to counter the latter.

The chemical composition of the overlay coatings used on super alloys is MCrAlX (where M is nickel and/or cobalt and/or iron and X is one or more reactive elements such as yttrium, hafnium, etc) (Warnes *et al*, 2003). Warnes *et al* (2003) goes on to explain that MCrAlX coatings are secondary aluminium oxide formers, that is, they initially form a chromic oxide external scale when exposed to an oxidizing environment at high temperature, then aluminium oxide forms under the chromic oxide layer.

Even though the overlay coatings are used and improve the corrosion resistance at elevated temperatures, applying the coatings can be difficult. Warnes *et al* (2001) explains that overlay coating techniques (plasma and flame spraying or physical vapor deposition) are line-of-site processes, and so, it is not possible to obtain uniform coating thickness on complex turbine components such as multiple vane segments. This could result in sections of the component not having any or the right thickness of coating, therefore hindering the performance of the component at elevated temperature.

Super alloys will constantly be developed, pushing them to new extremes as industrial processes change and the demand for higher temperatures and more durable machinery increases.

#### 1.2.1.3. Composition of super alloys

Super alloys have an interesting crystal structure which contributes to their physical and mechanical properties. The structure consists of a face-centered-cubic (fcc) crystal structure and a hexagonal close-packed (hcp) crystal structure. The addition of alloying elements alters the thermodynamic stability of the fcc and hcp phases by either enlarging or constricting their fields (Kuzucu *et al*, 1998). Kuzucu *et al* (1998) further explains that alloying additions of nickel, carbon, and iron tend to stabilize the fcc structure, whilst chromium, molybdenum and tungsten tend to stabilize the hcp structure. The addition of the correct alloying elements is vital in ensuring that both the fcc and hcp structure can withstand the extremes that the super alloy will encounter.

Gamma (γ) and gamma prime (γ') matrix are also mentioned in literature with regard to the structure of super alloys. Reed *et al* (2009) explains and supports Kuzucu *et al* (1998) that a significant number of elements are added to nickel, e.g. Al, Ti, Ta to impart strengthening via the $Ni_3$ (Al, Ti, Ta) phase which is known as γ', Re, W and Mo to improve creep resistance, and Al, Cr and Co to impart resistance to oxidation corrosion and sulphidation. Weather elements are added to stabilise the structure, increase the strength or resistance of the alloy they are important in improving the overall structure and performance of the super alloy.

The different alloying elements added to super alloys are distributed in the structure in different ways. Single-crystal nickel-base super-alloys have a high volume fraction of nickel

aluminide ($Ni_3Al$) (y' phase) precipitates distributed uniformly within a matrix of solution-strengthened Ni (y phase) (Nie *et al*, 2009). Yoon *et al* (2007) supports Nie *et al* (2009) by saying that the microstructure consists of ordered $Ni_3Al$ (L12) type precipitates (y') dispersed in a solid-solution, chromium-enriched, face-centered cubic (fcc) nickel matrix (y).
Super alloys are complex structures and can contain eight or more elements to make up the end product. Park *et al* (2011) looked at Alloy 617 which had the following elements: Ni, Cr, Co, Mo, Al, C, Fe, Mn, Si, S, Ti, B. This is a total of twelve elements in one alloy.
Zhang *et al* (2011) looked at super alloy K40S which has composition of: Co, C, Cr, Ni, W, Fe, Si, Mn, B which is a total of nine elements.
The super alloy that is being investigated in this project is CMSX-4 which is a second generation alloy and contains the elements Ni, Cr, Al, Co, Mo, W, Ta, Re, Ti and Hf (Li *et al*, 2000).

#### 1.2.1.4. Nickel (Ni)

Nickel is an important metallic element that is naturally present in the earth's crust (Denkhaus and Salnikow, 2002).
When mining for nickel it is usually found in two different ores, sulfide and laterite. Sulfide ores are typically derived from volcanic or hydrothermal processes (Mudd, 2010). Laterite ores on the other hand are formed near the surface following extensive weathering of ultramafic rocks (Mudd, 2010). Laterite ores are iron and aluminium rich soils which are usually rusty coloured due to iron oxides.
Nickel is a very versatile metal, Denkhaus and Salnikow (2002) states that pure nickel can be polished, forged, welded, rolled and drawn and is inert against corrosion by air, water, non-oxidizing acids, alkalis and many organic solvents.
Due to nickel's versatility it is used widely in modern infrastructure and technology, with major uses in stainless steel (58%), nickel-based alloys (14%), casting and alloy steels (9%), electroplating (9%) and rechargeable batteries (5%) (Mudd, 2010).
As technology and infrastructure has developed over the years the demand for nickel has risen from under 200 ktpa in 1950, to over 1200 ktpa in 2003 and was growing at an average of 4% pa (McDonald and Whittington, 2008).
Nickel is a metal that is widely used in super alloys and makes up a large proportion of the alloy. Choudhury and El-Baradie (1998) states that nickel-base alloys contain at least 50%

nickel. Park *et al* (2011) mentions that the most practical and applicable materials above 700°C are Ni-base alloys. This is supported by Reed *et al* (2009) who says that nickel-based superalloys are remarkable for their resistance to mechanical and chemical degradation at temperatures up to 1000°C and beyond. This feature of huge resistance even at extreme temperatures is why nickel is used for many super alloys.

#### 1.2.1.5. Cobalt (Co)

Cobalt is a metal that is used widely in industrial applications due to unique features. Safarzadeh *et al* (2011) identifies that cobalt is being widely used in many applications such as turbine blades for aircraft engines, hard facing alloys, magnets and superalloys because of some unique properties such as ferromagnetism, varying crystal structure with temperature, and wear and corrosion resistance properties. Ferromagnetism is where a material has the ability for form magnets which are permanent.

Kuzucu *et al* (1998) expands on what Safarzadeh *et al* (2011) has said regarding varying crystal structure by explaining that pure cobalt exists in two allotropes, a high temperature allotrope with face-centered-cubic (fcc) crystal structure, stable at higher temperature up to the melting point (1495°C), and a low temperature allotrope with hexagonal-close-packed (hcp) crystal structure, stable at temperatures below 417°C. Due to the complex structure of cobalt it means that it can withstand a wide range of temperatures, this makes it a good metal to use in super alloys.

Cobalt based super alloys have been widely used in stationary components for the hot section of gas turbine engines due to their good combination of high temperature strength and excellent hot corrosion resistance for long-term exposure (Zhang *et al*, 2011).

Warnes *et al* (2001) and Kuzucu *et al* (1998) both confirm what Zhang *et al* (2011) said by saying cobalt-based super alloys are used to manufacture stationary components (vanes, etc) for the hot section of gas turbine engines (Warnes *et al*, 2001) and that cobalt-base alloys are used extensively in applications requiring good wear resistance, corrosion resistance, and heat resistance.

Cobalt based alloys are also used in the medical industry due to structural properties. Due to its excellent resistance to degradation in the oral environment, the first medical use of cobalt-base alloys was in the cast of dental implants (Marti, 2000). This has spread and is now used for many orthopaedic prostheses.

#### 1.2.1.6. Chromium (Cr)

Chromium is a silvery coloured metal and is the seventh most abundant available element on the Earth and 21st in the Earth's crust, with an average concentration of 100 mg/kg (Sundaramoorthy *et al*, 2010). Mukherjee (1998) supports Sundaramoorthy *et al* (2010) and also says that chromium is the 21st most abundant in the earth's crust. Mukherjee (1998) further mentions that in nature, it does not occur in the elemental form, but the oxidation form of chromium (III) and chromium (VI). Baral and Engelken (2002) states that chromium occurs primarily in the trivalant state (III) and in the hexavalent state (VI). Elemental chromium (0) does not occur naturally on earth.

Baral and Engelken (2002) further explains that Chromium (Cr) is found in nature in rocks, soil, plants, animals, volcanic dust and gases.

Chromium compounds have many industrial uses, such as chromite ore processing, electroplating, leather-tanning processes amongst others (Quilntana *et al*, 2001). Sundaramoorthy *et al* (2010) mentions that chromium compounds are commonly used as tanning agents, textile pigments and preservatives, antifouling paints, wood preservatives, metal finishing and in electroplating.

Chromium is used for metal finishing in industries as it makes the products shiny, attractive, and wear and tear-resistant (Baral and Engelken, 2002).

Chromium is widely used in alloys as it helps enhance the overall performance of the alloy. Chromium alloyed with iron and cobalt is appreciated particularly due to their high oxidation, corrosion and heat resistance, as well as the excellent creep strength at high temperatures (Harada *et al*, 2003). Choudhury and El-Baradie (1998) mentions that many wrought nickel-base super alloys contain 10-20% Chromium. Choudhury and El-Baradie (1998) further say that chromium and aluminium are also necessary to improve surface stability.

Due to chromium's characteristics of enhancing oxidation, corrosion and heat resistance along with structural stability it has become an essential element to use in super alloys. Ternary Ni-Cr-Al (Nickel-Chromium-Aluminium) alloys are fundamental to the structure of multi-component nickel-based super alloys (Yoon *et al*, 2007).

#### 1.2.1.7. Aluminium (Al)

Aluminium is a silvery-white, non-magnetic metal which is both ductile and malleable (Housecroft and Constable, 2006) and has special properties in that it is a light, conductive and corrosion resistant metal (Tsakiridism, 2012). Housecroft and Constable (2006) support this by saying aluminium has high thermal conductivity and is very resistant to corrosion. The coating is created by a layer of oxide. Liu *et al* (2005) however, contracts this by saying that aluminium and aluminium alloy can be corroded easily in natural conditions. Liu *et al* (2005) does support Tsakiridism (2012), Housecroft and Constable (2006) that aluminium and its alloy have excellent properties, such as low density, high conductivity and easy machining. Housecroft and Constable (2006) go on to mention that the strength of aluminium can be increased by alloying with Cu (Copper) and Mg (Magnesium).
Aluminium is the most abundant metal and the third most abundant element in the earth's crust, after oxygen and silicon (Tsakiridism, 2012) and occurs to an extent of 8.1% (Housecroft and Constable, 2006). Due to its properties aluminium is widely used, with applications in the aerospace, architectural construction and marine industries, as well as many domestic uses (Tsakiridism, 2012). Chen and Graedel (2012) support the evidence that aluminium is widely used as they say aluminium is widely recognised for its technological versatility, and its rate of use now cedes first place only to steel among the metals.
There are two main routes in finding aluminium with the primary route being the use of strip mines to excavate bauxite ore. The second route is that of recycling aluminium from process scrap and then used in aluminium products (Tsakiridism, 2012). Chen and Graedel (2012) explain that although the energy required for producing secondary aluminium might be only 5-10% of that needed for primary aluminium, there are still substantial environmental emissions. Therefore the production of aluminium has a negative effect on the environment.
Aluminium is used as a coating for super alloys in its aluminide form (aluminium bonded together with metals that easily share electrons). Aluminide coatings have been used to provide high temperature oxidation resistance to nickel based alloys for decades (Warnes *et al*, 2001).

### 1.3. Refractory elements

#### 1.3.1. What are refractory metals?

Refractory metals are a group of metals on the period table that have special properties such as high melting points above 2000°C. They are all resistant to heat and degradation. Due to their properties of being heat and wear resistant, it makes them extremely useful when added to super alloys to improve the ability of the alloy to withstand high temperatures and extreme stresses. Walston *et al* (1996) states that the development of third generation single crystal alloys proceeded with increases in refractory element content. Yoon *et al* (2009) support this by saying refractory alloying elements Ta, Re, Mo and W have been added to third generation commercial super alloys. Apart from use in super alloys, they have also been of crucial importance for all existing types of industrial light sources (Eichelbrönner, 1998). Eichelbrönner (1998) explains that the refractory elements comprise of tungsten, molybdenum, niobium, tantalum, rhenium, zirconium and hafnium.

Niobium and zirconium will not be looked at in this review as they are not used in the super alloy CMSX-4.

#### 1.3.2. Titanium (Ti)

Titanium is the ninth most abundant element in the earth's crust and the fourth most abundant element (Zang *et al*, 2001) and the world market for titanium is estimated to be between 40 and 50 million kilograms annually (Bauer *et al*, 2010). Titanium is found in minerals with the main titanium-containing minerals being rutile, ilmentie and leucoxene (Zang *et al*, 2001) with Rutile containing about 95% $TiO_2$ and is the most titanium-rich mineral (Zang *et al*, 2001).

Titanium is a white metal when pure and is a familiar metal used in the jewellery industry in recent years. Titanium and its alloys however, are used in various fields such as the aerospace, marine, and vehicles industries (Bauer *et al*, 2010). In 1948 driven by the demand from the aero craft industry (Zang *et al*, 2001) titanium became commercially produced. Titanium has characteristics that make it a versatile metal, one characteristic is titanium's corrosion resistance, which has made it useful in chemical industry. The realisation that titanium exhibited remarkable corrosion resistance in oxidising chloride environments led to some of its first applications in the chemical process industry (CPI), such as wet chlorine gas coolers for chlor-alkali cells, chlorine and chlorine dioxide bleach equipment in pulp/paper mills, and reactor internals for pressure acid leaching of metal ores (Thomas, 2003). Thomas (2003) explains that titanium's corrosion resistance relies upon the formation of a very thin oxide film, which occurs spontaneously in air or water. If this layer becomes damaged and cannot regenerate then the rate of corrosion is increased dramatically. Thomas (2003) also mentions that titanium should never be used in the presence of hydrofluoric acid. Extremely high corrosion rates are observed even at parts per million (ppm) concentrations.

Titanium has also been widely used in the medical industry due to it having high corrosion resistance and also high biocompatibility. Kikuchi (2009) explains that for its excellent biocompatibility and corrosion resistance as a dental structural material, titanium has been successfully used for manufacturing dental implants and prostheses. Bauer *et al* (2010) agrees with Kikuchi (2009) and says that in the dentistry field, titanium (Ti) is mainly used due to the high biocompatibility and low density when compared with other alloys used in dentistry (Co-Cr and Ni-Cr) and good strength-to-weight ratio, corrosion resistance and low cost when compared with gold alloys.

### 1.3.3. Tungsten (W)

Tungsten is a transition metal found, along with chromium, molybdenum and seaborgium, in Group VI of the Periodic Table (Koutsospyros *et al*, 2006). Tungsten is found in the earth's crust and is by far the most significant source of tungsten in the ecosphere and is estimated to contain 0.00013% W on a mass basis (Koutsospyros *et al*, 2006).

Tungsten is a transition metal and a refractory metal that is characterised by its very high melting point (3420°C), high density (19.3g/cm$^3$), low coefficient of thermal expansion (4.4 ppm/K at 20°C) and superior mechanical properties at elevated temperatures (Mondal *et al*, 2010). Both Gong *et al* (2012) and Koutsospyros *et al* (2006) agree that tungsten has an extremely high melting point (about 3420°C) with Koutsospyros *et al* (2006) explaining that tungsten has the highest melting point of all elements (except carbon) and a boiling point of 5660°C.

Tungsten exhibits a series of excellent properties as a refractory metal. It has been used in a wide range of industrial and national defence systems (Luo *et al*, 2009). Huang *et al* (2009) comments on how tungsten has been extensively used in light bulbs, vacuum tube filaments and electrodes due to its excellent physical and chemical properties. Mondal *et al* (2010) supports this statement by also explaining that tungsten is highly suitable for many engineering applications such as lightning filaments, heating source, aerospace, electronic devices, sport and military uses, etc.

Tungsten is commonly considered as a solution strengthening element (Yan *et al*, 2011). This is probably due to the way tungsten is structured within an alloy. Gong *et al* (2012) explains that the use of backscattered scanning electron microscope (SEM) indentified that the structure of tungsten heavy alloys mainly consist of spherical tungsten particles interspersed in a matrix phase with lower melting elements (Ni, Fe, Cu, Cr, Mo and Co).

Yan *et al* (2011) looked at the effect of tungsten on the microstructure of super alloy HK40 and reported that, although tungsten increased the tensile strength and low-cycle fatigue resistance of HK40 alloy, it had a negative impact on it ductility.

It would appear that an increase in tensile strength and a negative impact on ductility is a characteristic of tungsten in super alloys. Gong *et al* (2012) also examined the effect of tungsten on the microstructure of super alloys, in this case, Tungsten Heavy Alloys (W-Ni-Fe), and also came to the same conclusion that the ultimate tensile strength and hardness can be markedly increased but with a decreased ductility.

#### 1.3.4. Tantalum (Ta)

Tantalum is part of the refractory metal group and like all other refractory metals it is dense and has a high melting and boiling point. Cardonee *et al* (1995) states that tanatalum is a very dense material (16.6g/cc), tantalum has very high melting (~3100°C) and boiling (~5425°C) points. Tantalum was discovered in 1802, however, this highly versatile refractory metal has seen use in significant quantities only in the last 50 years (Cardonne *et al*, 1995). This was written in 1995 so that would mean tantalum has been used significantly for the last 68 years to date.

Tantalum is used in electronics, in cutting alloys, in chemical manufacturing as a catalyst and acid resistant materials (Agrawal, 2002). Cardonne *et al* (1995) go on to say that primary uses of tantalum and its alloys are in electrical capacitor manufacture, electronics, superalloys, medical and high temperature applications and chemical processing. Tantalum is also used in the medical field as a supporting gauge in the repair of hernias, as a dressing for burns, in prosthetic applications and local radiation for bladder cancer after neutron activation (Agrawal, 2002). Flecher *et al* (2010) supports Agrawal (2002) as the literature talks about the characteristics and applications of tantalum in orthopaedic surgery.

### 1.3.5. Molybdenum (Mo)

Molybdenum is a silvery-grey metal with a high melting point of 2620°C (Ambroziak, 2011). Molybdenum is used as an alloying agent in steel, as welding electrodes, in petroleum refining and for nuclear energy applications (Burguera *et al*, 2002). Molybdenum is used in the industrial sector, but also in medicine and is a necessary element for the human body and plants (Wang *et al*, 2009). Filik *et al* (2009) agrees that molybdenum is needed by biological organisms by saying that it is a bio-essential nutrient element, however Filik *et al* (2009) goes on to say that molybdenum is toxic to humans when present in high concentrations. Burguera *et al* (2002) also mentions that molybdenum is an essential trace element for plants, animals and microorganisms. Molybdenum is considered to be the most important refractory metal, despite the fact that merely 6% of its total production is processed into structural metal (Ambroziak, 2011). The importance of molybdenum is probably the reason it is used in super alloys as components made of molybdenum can work at high temperatures (Ambroziak, 2011). If molybdenum is alloyed with certain metals it can improve the strength of the end product. Titanium and zirconium have a hardening effect on the solid solution. As a result, the strength properties improve in comparison with pure molybdenum (Ambroziak, 2011).

In nature molybdenum can be found at very low concentrations in plants, natural water and seawater and other aqueous matrices (Filik *et al*, 2009) however the main source of molybdenum is from molybdenite ($MoS_2$) which is generally a by-product from copper mining (Askari Zamani *et al*, 2005).

### 1.3.6. Hafnium (Hf)

Hafnium is a silvery gray metal which has very similar properties to zirconium. Simultaneous determination of zirconium and hafnium is extremely difficult due to the great similarity of their behaviour (Oszwaldowski *et al*, 1998). Hafnium occurs in all zirconium ores in the range of 2-3% (Smolik *et al*, 2009). Reddy and Kumar (2005) agrees with this by stating that hafnium is always associated with zirconium ore and is available as a by-product of the production of zirconium metal. The average concentration of hafnium in the earth's crust is estimated at 2.8 - 2.5ppm (Reddy and Kumar, 2005).

Hafnium is used in different manufacturing areas but most of the produced hafnium is currently used in super alloys because it improves the mechanical properties and oxidation resistance particularly at high temperatures (Abdelkader and Daher, 2009). Reddy and Kumar (2005) support this by also saying the largest use is as an alloying additive (1-2%) in nickel based super alloys. They go on to mention that the second major use of hafnium is as control-rod material in nuclear reactors. Abdelkader and Daher (2009) also explain that hafnium has been known for years as a control rod material in the nuclear reactor due to its high thermal neutron cross section and its high corrosion resistance at elevated temperatures. Hafnium is also used in the electronic industry in products such as integrated circuits, condensers and permanent magnets (Abdelkader and Daher, 2009).

### 1.4. Rhenium (Re)

Rhenium is a silvery-white, heavy metal which exhibits special properties such as high melting and boiling points, making rhenium useful in the industrial business where highly resistant components are required for mechanically demanding applications. Rhenium has a hexagonal close packed crystal structure and has chemical properties similar to those of Technetium (Tc) (Tagami and Uchida, 2000) and (Tagami and Uchida, 2008) along with similar electronic configuration, stereochemistry and thermodynamic properties (Kim *et al*, 2004) which is why they are both placed in group seven on the periodic table. Rhenium is distributed widely in nature, however it is extremely rare that it can only be found on the earth's surface in parts per billion (Leddicotte, 1961).

Tagami and Uchida (2008) supports Leddicotte (1961) by explaining that natural rhenium, which is a mixture of two isotopes, $^{185}Re$ and $^{187}Re$ have concentrations in the earth's upper crust of about 0.4ng $g^{-1}$, 2.2pg $mL^{-1}$ in world average river water, and 7-8pg$mL^{-1}$ in seawater. Rhenium however is not found as an individual mineral in nature, instead it exists in molybdenite (Xiong *et al*, 2008).

Rhenium recovered from molybdenite concentrates is recovered in Chile, USA and Germany and is recovered from copper smelters in Kazakhstan and Poland (Abisheva *et al*, 2011). Small amounts of rhenium are separated from relatively large amounts of molybdenum (Mozammel *et al*, 2007). The initial recovery concentrations of rhenium in solutions from

Kazakhstan are more than 200mg/dm³ whereas the Polish average is around 30mg/dm³ of rhenium (Abisheva *et al*, 2011).

Laddicotte (1961) explains that rhenium occurs in its highest concentration in molybdenite and in some platinum ores. This is supported by Mozammel *et al* (2007) who states that the best sources of rhenium are molybdenite concentrates and flue dust from molybdenite roasters.

Due to rhenium's rarity and the increasing use of rhenium in industry in recent years it is in short supply on the world market (Xiong *et al*, 2008) which has lead to the price of rhenium to increase and in recent years, the world market price has varied between 6,000 - 10,000 USD (Abisheva *et al*, 2011).

### 1.4.1. Uses of Rhenium

Despite the expense of rhenium, today's industry and technologies has increased its use and it is now a popular and widespread element to work with, ranging from medicine to defence and fission space reactor designs (Leonard *et al*, 2007).

Both Lan *et al* (2006) and Zhan-fang *et al* (2009) mention that rhenium is a less common metal with special properties which makes it widely used in the petrochemical industry, aviation, electron, medicine and metallurgy. Abisheva *et al* (2011) supports Lan *et al* (2006) and Zhan-fang *et al* (2009) explaining that in the 21st century, the main consumers of this metal (rhenium) are petrochemistry, aviation and space.

In medicine, rhenium isotopes have been used as labelling agents. Kochličková *et al* (1999) describes how the isotopes of rhenium $^{186}Re$ and $^{188}Re$ are widely used as labelling agents in nuclear medicine, because of their favourable nuclear properties. It has also been mentioned that rhenium and its alloys are quite suitable for use in gun tube coatings and liners (Garrett *et al*, 2006).

Rhenium been developed into the use of super alloys and the benefits of the use of rhenium in these remarkable metals has expanded over the years. Additions of this element were first made in the late 1970s which led to a widespread appreciation of the benefit of rhenium alloying (Mottura *et al*, 2010).

Yamini *et al* (2008) explains that rhenium's two most important uses in the past decade have been in platinum-rhenium catalysts used primarily in producing lead-free, high-octane gasoline and in high temperature super alloys for jet engine components. Rhenium is also used in turbine blades (Mottura *et al*, 2008).

### 1.4.2. Properties of Rhenium in super alloys

Rhenium is a special element which has many properties that significantly contribute to the effective super alloys that are used in industry, where a highly specialised material is needed to cope with the extreme temperatures and stress and strain that are created in some industrial processes. In fact, one of the key differences in the different generations of super alloys is the quantity of rhenium that is used. Second generation single crystal super alloys such as CMSX-4, PW1484 and René N5 contain about 3% by weight of rhenium, with high concentrations of this element in the third generation alloys (Rae and Reed, 2001).
Adding rhenium to super alloys increases the point at which the super alloy could melt as rhenium has a melting point of 3150°C (Leddicotte, 1961).
Rhenium is used to significantly improve the creep resistant to super alloys which is vital if the alloy is to withstand the stresses and strains endured.
Mottura *et al* (2010) explains that rhenium has been found to improve markedly the creep resistance of these materials. Mottura *et al* (2008) agrees with this, describing that rhenium plays a key role in promoting creep resistance of these materials; it is, however, unclear how rhenium improves the creep properties (Mottura *et al*, 2010).
The hardness of super alloys is important in producing an effective material. The higher the hardness of the super alloy, the less prone it is to deform under extreme stresses. The different generations of nickel-based super alloys clearly show a rising hardness of the y(gamma)-matrix with a higher concentration of rhenium, however no significant difference has be found in the y'(gamma prime) -precipitates (Burst and Göken, 2004). Garrett *et al* (2006) has also found that rhenium has the highest work hardening coefficient of any metal. Garrett *et al* (2006) goes on to explain that rhenium is very ductile, has a high tolerance for carbon and hydrogen, a high melting point, and no brittle-to-ductile transformation.
Rhenium also plays an important role in the coarsening rate of super alloys structures. Durst and Göken (2004) mentions that rhenium reduces the coarsening rate of the y'-particles. This means that the fine particles within the super alloys take longer to clump together at fluctuating temperatures, therefore helping to keep the integrity of the super alloy structure intact.

All these characteristics make rhenium a valuable element to use in super alloys. Rhenium, when combined with other elements with special properties can improve super alloys even further. Tungsten, molybdenum and rhenium are added since they are known to be potent solid solution strengtheners (Rae and Reed, 2001). Solid solution strengtheners are elements that, when added to a base element, for example, nickel or cobalt, diffuses into the base element matrix, creating a solid, strengthened structure.
Another example of rhenium being added to super alloys with other elements is rhenium and molybdenum which is used together to improve the ductility, toughness and has long been recognised (Leonard *et al*, 2007).
Despite rhenium's significant contribution to producing effective super alloys, the use of rhenium increases the overall cost of the product, therefore, rhenium may be alloyed with other metals to reduce material cost while maintaining the desirable performance properties of rhenium itself (Garrett *et al*, 2006).

**1.5. Molecular Imprinted Polymers (MIP)**

1.5.1. What are Molecular Imprinted Polymers?

Molecular imprinted polymers work in a very similar way to the 'lock and key' effect which occurs in biological environments when enzymes and substrates come together, a specific substrate will only bind with the enzyme which has the substrates identical shape and size missing. Molecular imprinted polymers are synthesised in chemical industries and offer artificial recognition sites, which are able to specifically rebind a target molecule in the presence of similar compounds (Vatanpour *et al*, 2011). Dong *et al* (2007) supports Vatanpour *et al* (2011) in explaining that molecular imprinting is effective in encoding molecular information (shape, size and functional groups orientation) in bulk materials. This means that a molecular imprinted polymer can be synthesised to recognise an analyte and then once produced, even if there are many molecules which are similar to the one of interest, the molecular imprinted polymer will be able to distinguish between them all and select the correct analyte of interest.

Molecular imprinted polymers started to be developed in the 1970s, Wulff's group in the early 1970s on the development of MIPs for sugar and amino acid derivatives, MIPs for over 20 classes of compounds have been reported. The list includes sugars, amino acids, peptides, proteins, therapeutic drugs, steroid, metal ions, aromatic hydrocarbons, dyes, phosphonate esters, and pesticides (Merkoçi and Alegret, 2002). Metal ion imprinted polymers were historically introduced in 1976 (James *et al*, 2009), which have remarkable features such as large number of binding sites, high surface area and porosity, faster binding kinetics and selective affinity (James *et al*, 2009). Ion-imprinted polymers (IIPs) are similar to MIPs but recognize inorganic ions after imprinting (Saraji and Yousefi, 2009), furthermore, ion imprinted polymers (IIPs) like molecular imprinted polymers (MIPs) can work under extreme conditions like low and high pHs, higher temperatures and pressures and also extremely toxic environments (Kala *et al*, 2004).

Due to imprinting polymers versatility they have become very popular, the most promising materials in the field of artificial molecular recognition systems are molecular imprinted polymers (Merkoçi and Alegret, 2002). He *et al* (2007) also agrees that molecular imprinted polymers have become popular and explains that, in recent years, molecularly imprinted polymers (MIPs) have attracted much attention due to their outstanding advantages, such as predetermined recognition ability, stability, relative ease and low cost of preparation, and potential application to a wide range of target molecules.

### 1.5.2. How do they work?

In order for Molecular Imprinted Polymers to be successful in the removal of the analyte of interest they must contain specific characteristics, MIP's must contain the following: A target molecule; a monomer (also known as a functional ligand); a cross linker; an initiator; and a porogen. These get combined together and then heated/irradiated to allow the mixture to polymerise and turn from a liquid into a solid. Polymerisation is a process where a chemical reaction takes place in the presence of monomer molecules, which, in turn form long continuous polymer chains.

Moring *et al* (2002) explains that molecular imprinted polymers are generally prepared by polymerization of functional monomers and a cross linker in the presence of a template molecule in a porogen solvent system. Both Saraji, Yousefi (2009) and Zambrzycka *et al* (2011) describe a similar process to Moring *et al* (2002). In the process of molecular imprinting, appropriate functional monomers are introduced to interact with template molecules, and then the functional groups on the monomers are fixed with chemical cross linkers (Saraji and Yousefi, 2009). Zambrzycka *et al* (2011) describes that the synthesis is

made by assembly of monomers around a template molecule and a subsequent polymerization using a cross-linker.
During the polymerisation process, the initiator, which is a molecule that can easily be converted into a free radical, kick starts the polymerisation process by 'attacking' the crosslinker and monomer in order to turn them into free radicals to allow for the different molecules to interlink with each other. The monomer attaches itself to the template molecule during the polymerisation process, usually by covalent or non-covalent bonding. Zambrzycka *et al* (2011) says the formation of complexes of monomers with the analyte (template) can be based on covalent or non-covalent bonds which is supported by He *et* al(2007) who mentions that monomers form a complex with a template through covalent or non-covalent interactions and are joined by using a cross-linking agent. García-Calzón and Díaz-García (2007) states that molecular imprinting may be classified into covalent imprinting (pre-organized approach), non-covalent imprinting (self-assembly approach) and semi-covalent imprinting, according to the type of interactions involved between the functional monomers and the template in the pre-polymerisation mixture and during rebinding. Depending on how the monomer and template interact, this will determine what processes should be used in the removal of the template.

Once polymerisation has taken place the template needs to be removed in order to be able to extract the analyte of interest. There are different ways in which the template can be removed. One way to remove the template is by washing with an acid solution. Zambrzycka *et al* (2011) says that after polymerisation, the template molecules are removed by extensive washing steps to disrupt the interactions between the template and monomers. He *et al* (2007) mentions that another way of removing the template is by chemical reaction or extraction. Moring *et al* (2002) used an extraction method for the removal of the template as the polymer was extracted in 100ml methanol in a Soxhlet apparatus for 4hours.
After the removal of the template the MIP contains voids where the template was, which is analyte specific. All literature agrees with this theory. Singh and Mishra (2010) describes that once the template is extracted it leaves sites which are complementary in both shape and chemical functionality to those of the template. Zambrzycka *et al* (2011) writes a very similar description, saying that the prepared polymers contain imprinting sites of a

complementary shape and functionality to the template molecules. Saraji, Yousefi (2009), Merkoçi and Alegret (2002) agree as well with the statement, mentioning that the extraction of the template molecules leaves a predetermined arrangement of ligands and a tailored binding pocket (Saraji and Yousefi, 2009) and the material retains its moulded shape to fit and coincide with that of the template molecule (Merkoçi and Alegret, 2002). Now that the template is removed the analyte of interest can be introduced into the MIP. Due to the specific binding sites this allows for selective uptake of the intended analyte even in the presence of undesired molecules. Once the analyte of interest is attached to the MIP it can then be removed, usually by the same means in which the template was removed.

### 1.5.4. Uses of Molecular Imprinted Polymers

Molecular imprinted polymers have become increasingly used over the years and due to their remarkable selectivity the range in which they are used has expanded greatly. MIPs have been widely used as artificial receptors in separations, sensors, catalysis and drug development and screening (He *et al*, 2007). Dong *et al* (2007) agrees with this and says that effort has been made to try and apply the molecular recognition capability of MIPs to biosensors, antibody and enzyme mimics, chiral separation and solid phase extraction.

He *et al* (2007) goes on to mention that MIPs are successfully used as sorbents for cleaning up and selectively enriching analytes from different real samples, such as environmental, biological, food, drug and other real samples. Due to the diverse range that MIPs can be used in the have attracted attention in the scientific community (García-Calzón and Díaz-García, 2007). Moring *et al* (2002) mentions that molecular imprinted polymers (MIP) can be used for highly selective isolation of specific analytes for sample preparation when used as MIP solid phase extraction media. Zhai *et al* (2008) also talks about how instead of columns filled with particles, membranes have become increasingly attractive for efficient separation due to their promising properties of ease and low energy of operation.

The ease and low energy of operation, along with relatively low cost and speed in which they can be produced is also another reason why MIPs have become increasingly attractive to use as an alternative separation technique. The principal advantages of this technique are easy preparation of the template and the monomer complex, fast binding of templates to molecularly imprinted polymers, good selectivity, and possibilities of application of such sorbents for the SPE separation of wide range of target molecules from different matrices

(Zambrzycka *et al*, 2011). He *et al* (2007) supports Zambrzycka *et al* (2011) by stating that there are several advantages to this technique including easy preparation of the template/monomer complex, easy removal of the templates from the polymers, fast binding of the templates to MIPs, and its potential application to a wide range of target molecules. Merkoçi and Alegret (2002) further mentions that compared with natural molecular recognition products, such as antibodies, MIPs bring several advantages, such as low-cost, predictable specificity, durability and mass production.

### 1.5.5. Molecular imprinted polymers on metal separation

Another area where molecular imprinted polymers have been utilised is in the separation of metals. A range of metals have been investigated over recent years, for example, Say *et al* (2003) created a ion imprinted polymer for the extraction of copper (Cu(II)) from aqueous solutions. Methacryloylamidohistidine (MAH) was used as the complexing monomer and EGDMA was used, along with 2,2-azobisisobutyronitrile (AIBN). EGDMA and AIBN would be used as the crosslinker and initiator respectively. Say *et al* (2003) concluded that pH was an important factor influencing the adsorption of the copper, with pH7.0 being the optimum condition in the study. Say *et al* (2003) produced a polymer that had a maximum adsorption of 48mg/g of Cu(II) and the polymer was highly selective towards Cu(II) even in the presence of zinc; nickel; cobalt which have similar ionic radii.

Zambrzycka *et al* (2011) looked at the separation of ruthenium (Ru(III)) using two different reagents to complex with the ruthenium, thiosemicarbazide (N-aminootheiourea) (TSd) and acetaldehyde thiosemicarbazone (AcTSn). Methacrylic acid was used as the functional monomer, while EGDMA and AIBN were used as the cross-linker and initiator respectively. The results of Zambrzycka *et al* (2011) showed that the removal of Ru(III) ions were possible at pH7.5. Using TSd as the complexing reagent gave a recovery of 72.9 - 93.8%, while the Ru-AcTSn polymer gave a recovery of 80.5 - 104.4%. The results also showed that over a hundred cycles, the adsorption capacity of both polymers did not diminish. These results indicate that these polymers could be very useful in the analysis of platinum group metals in environmental samples (Zambrzycka *et al*, 2011).

Singh and Mishra (2010) created an Ion imprinted polymer to remove nickel(II)ions from artificial sea water samples. They used 2-hydroxy ethyl methacrylate (HEMA) with nickel vinyl benzoate complex which was cross-linked with EGDMA. They concluded that separation of nickel ions was achieved, even in the presence of Zn(II), Cu(II) and Co(II). Singh and Mishra (2010) further mentioned that the porosity was an important factor as it could change the surface area of the adsorbent and thus increase the selective removal of Ni(II) ion from complex matrices. pH was also investigated and concluded that the optimal pH was 6.5.

Vatanpour *et al* (2011) also created an ion imprinted polymer for the separation of nickel(II) ions. Vatanpour *et al* (2011) used EGDMA as the crosslinker and AIBN as the initiator, the same as Singh and Mishra (2010). The complexing agent to the nickel however, was different, as Vantanpour *et al* (2011) used dithizone to complex with the Ni(II) ions. Their results showed that selective permeation of Ni(II) versus Co(II) was observed and that after the fifth cycle of adsorption/desorption, the adsorption capacity of the recycled polymer was maintained around 90% of the original value. Vantanpour *et al* (2011) observed that the optimum pH for high adsorption was pH8 and for high selectivity, pH7 should be used.

Molecular imprinted polymers have also been made for the separation of chromium. Birlik *et al* (2007) used methacryloylamdohistidine (MAH) as the complexing monomer for Cr(III). EGDMA and AIBN were used as the cross-linker and initiator respectively. It was concluded that the polymer had a high adsorption rate, with saturation being reached within 30 minutes and a sorption capacity of 69.28mg/g. Birlik *et al* (2007) also concluded that the polymer could be used in harsh mediums, such as concentrated acids and high temperatures and could be used many times without losing its sorption capacity.

Bayramoglu and Arica (2011) also investigated the separation of chromium, this time Cr(VI) using ion imprinted polymers. 4-vinyl pyridine was used as the complexing monomer which differs from the complexing monomer Birlik *et al* (2007) used, however, both Birlik *et al* (2007) and Bayramoglu and Arica (2011) used EGDMA and AIBN in their studies. Bayramoglu and Arica (2011) also tested their polymer on artificial waste-water which was found to be perform effectively in the removal of Cr(VI) without any significant interferences from other metal ions commonly present in waste-water. Like Birlik *et al* (2007), Bayramoglu and Arica

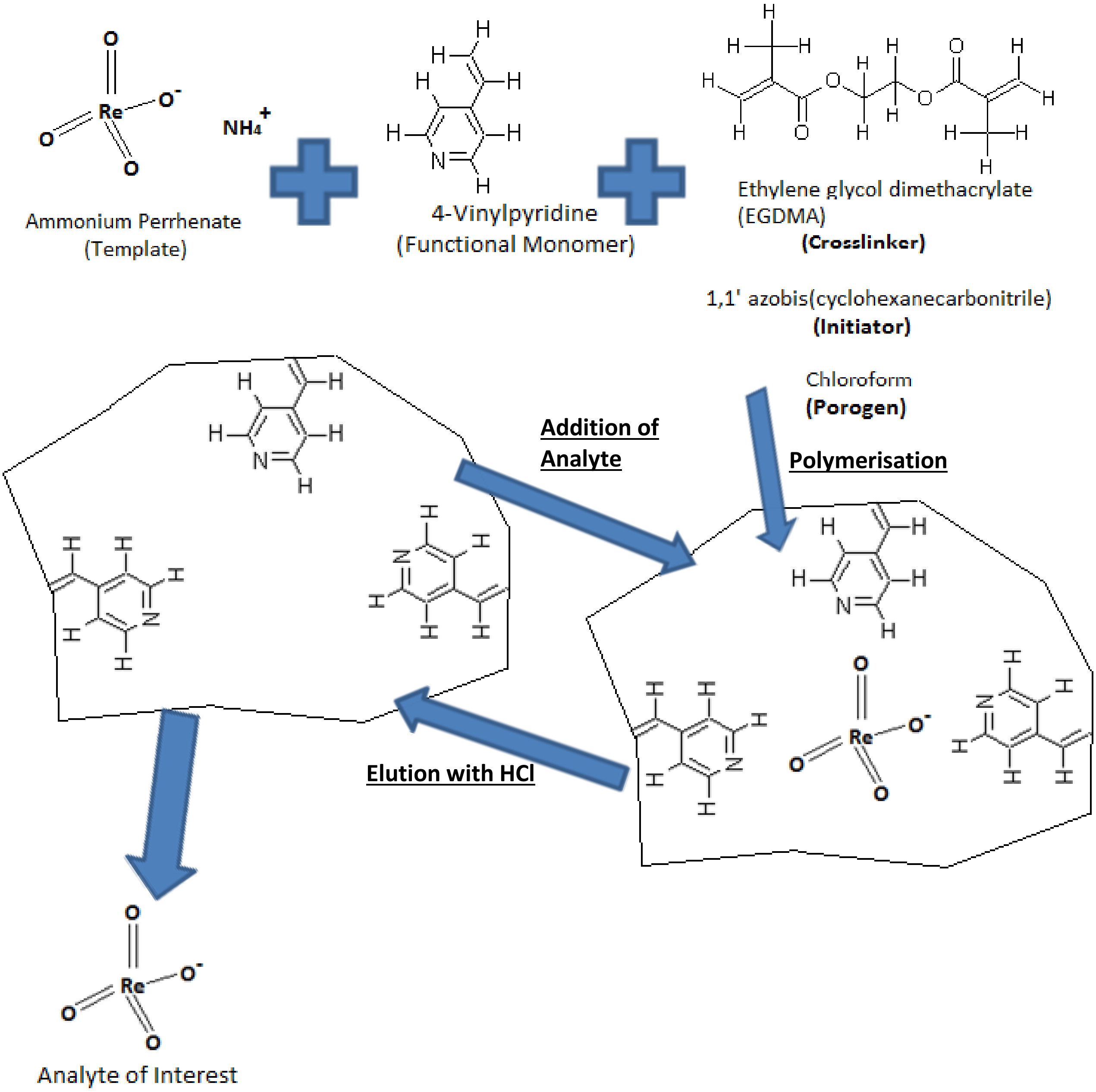
(2011) concluded that the polymer produced could be re-used on multiple occasions without loss in adsorption capacity.

Looking at the literature, a common theme seems to be evident. The cross-linker, EGDMA and the initiator, AIBN seem to be the most widely used reagents and this indicates that EGDMA and AIBN are a generic, effective combination that works for a variety of different analytes. EGDMA is a good molecule to use as it is a long carbon chained molecule that can be changed into a free radical and so can create a cross linking network which stabilises and hold the MIP in place. ABIN seems to be the choice for the initiator as it can easily be converted into a free radical upon heating. The differences in the literature are that of the functional monomers and complexing reagents with the analyte of interest, to form a template. From the literature it can be concluded that understanding the interactions between the functional monomer and complexing reagent to form a successful template is key to being able to produce an MIP that can effectively remove the analyte of interest. Furthermore, finding the optimum pH seems to be an important factor in finding the maximum adsorbing and selectivity capacity of the MIP.

### 1.5.6. Molecular Imprinted Polymers in this study

In this study, following the principles found in literature, the template of ammonium perrhenate will be added to a functional monomer, crosslinker, initiator and porogen. The solution will be polymerised, creating a molecule held together by the crosslinker with the functional monomer holding the template in place. Using an acid, the template will be removed and then the analyte can be added. Using the same method for the template removal, the analyte can eventually be removed from the MIP.

Fig. 1 - Designed schematic of the MIP process in this study




## 1.6. Analytical Techniques

### 1.6.1. Fourier Transform Infrared Spectroscopy (FT-IR)

Fourier Transform Infrared Spectroscopy (FTIR) uses the infrared spectra to bombard the sample with energy, which in turn affects the way the bonds within the sample behave by making them bend, stretch or vibrate. These changes to the bonds get detected and a spectrum of the sample can be produced from it. This technique is very useful in getting an in-depth picture of how molecules within a sample are bound together. FTIR is an analytical technique based on the frequency at which chemical bonds vibrate when subjected to electromagnetic radiation passing through (transmission mode), or reflected off (reflection mode), a subject of interest (Wysoczanski and Tani, 2006). FTIR has many uses and can be used for both qualitative and quantitative analysis (Anbarasan and Dhanalakshmi, 2010). Wysoczanski and Tani (2006) agree by also saying that FTIR spectroscopy can be used to both qualitatively and quantitatively measure these elements. FTIR is a useful tool in various science and engineering fields (Anbarasan and Dhanalakshmi, 2010) but is also used in food industries. Meng *et al* (2012) states that FTIR spectroscopy has found extensive use as an alternative technique to standard wet analytical techniques used to determine key quality parameters associated with edible fats and oils and, most recently, lubricants. FTIR is also widely used for the polymer industry in which it can easily identify raw rubbers (Chakraborty *et al*, 2007). In the case of molecular imprinted polymers, FTIR has demonstrated to be a valuable tool for deeper investigation of the binding mechanism with samples in solution and in the solid state (Cela-Pérez *et al*, 2013). FTIR has become a useful tool in many fields because of its high sensitivity or detectivity towards trace amount of samples, low noise to signal ratio and the method is an easy and inexpensive one (Anbarasan and Dhanalakshmi, 2010).

### 1.6.2. X-ray Fluorescence (XRF)

X-ray fluorescence (XRF) analyser, bombards samples with high energy photons (from a source) which can lead to the ejection of an electron from an inner shell of an atom (Lanford *et al*, 20005). Once the inner electron has been removed, an outer shell electron falls to fill the inner shell vacancy as the atom relaxes to the ground state (Kalnicky and Singhvi, 2001). The movement of an electron from the outer shell to the inner shell releases energy and the difference in energy between the two energy levels is released in the form of an x-ray (Langford *et al*, 2005). Kalnicky and Singhvi (2001) support this theory by saying that this process gives off photons with energy in the x-ray region of the electromagnetic spectrum equivalent to the energy difference between two shells. An excitation source (x-ray tube, radioisotope, etc) is used to irradiate a sample which in turns fluoresces and the atoms fluoresce at specific energies when excited by x-rays (Kalnicky and Singhvi, 2001). Apart from having an electron source, there needs to be a detector in order to gain results. The x-ray detector converts the energies of the x-ray photon into voltage pulses that can be counted to provide a measurement of the total x-ray flux (Kalnicky and Singhvi, 2001). There are a few different types of detectors such as a Si(Li) detector, which was used in the study by Al-Eshaikh and Kadachi (2011). A positive-intrinsic-negative (PIN) diodes or Silicon drift detectors (Langford *et al*, 2005) or a gas flow proportional detector, a scintillation detector or the solid-state semiconductor detector (Kalnicky and Singhvi, 2001).

The XRF can either be a large laboratory instrument or a portable instrument that can be used out in the field. This ability to use the instrument out in the field, along with its non-destructive nature on the samples, it has become a popular analytical tool. Černohorský *et al* (2006) explained that the benefits of XRF technique are namely non-destructive quick measurements and very little or no sample preparation. Al-Eshaikh and Kadachi (2011) agree with this and state that it is fast, accurate, non destructive and has a limit of detection in the range of a few part per million (ppm) of most elements. This indicates that the XRF is a good instrumentation to use on low concentration samples. The XRF can be used on a large variety of applications such as environmental samples, including soils, dust collected on air monitoring filters or wipe samples, rocks and metal samples (Radu and Diamond, 2009). The XRF has begun to play a crucial role in the analysis of precious metallic alloys (Černohorský *et al*, 2006) and is also used in areas such as paint, glass, pottery and ceramics, metals and alloys, soil, plastics and fabrics (Langford *et al*, 2005). The samples can be in the form of solid, powder or liquid (Al-Eshaikh and Kadachi, 2011) and both qualitative and quantitative analysis can be performed on the samples.

### 1.6.3. Scanning Electron Microscopy - Energy Dispersive X-ray (SEM-EDX)

Scanning Electron Microscopy (SEM) is a high resolution microscope that uses a beam of electrons to produce a detailed image of the sample. When an SEM is coupled with an Energy Dispersive X-ray (SEM-EDX) not only is an image of the sample produced, but the EDX can detect the chemical composition of the sample. Fifield and Kealey (2000) state, that one current development employs the electron beam within a scanning electron microscope to provide both a visual picture of the surface of the sample and an elemental analysis of the section being viewed.

The SEM works by focusing a stream of electrons into an extremely narrow beam. This beam repeatedly scans a portion of the surface of the sample in a series of parallel lines (Jackson and Jackson, 2004). The variations in the intensity of a signal being produced by the interaction of the beam with the samples surface (Jackson and Jackson, 2004) produce the image. The EDX works in a similar way to the XRF, where a beam of x-rays is focused on the sample, which in turns excites the atoms in the sample. When an electron from the inner orbital gets kicked by an x-ray, an electron moves from the outer shell to the inner, producing energy in the form of an x-ray. The energy released in this process is dependent on the size of the element and the size of its corresponding electron shells making it possible to distinguish between elements using this method.

SEM provides high resolution in combination with good depth of field, and with an energy dispersive X-ray spectrometer attached it identifies chemical composition within a microstructure at one location simultaneously (Sturm *et al*, 2012). For this reason it has become a powerful tool for forensic purposes because one can examine objects considering their morphology and the elemental composition (Zadora and Brożek-Mucha, 2003). SEM-EDX has also become widely used in the material science and engineering (Sturm *et al*, 2012). A big benefit of using SEM is that the spatial resolution is superior to that of normal light microscopes. Spatial resolution is a measure of the ability to tell apart features that are physically close together and an SEM is capable of a spatial resolution of 4nm (Jackson and Jackson, 2004) unlike light microscopes which have spatial resolution of 200nm (Jackson and Jackson, 2004). This means an extremely detile dpicture of the sample being examined can be formed.

### 1.6.4. Inductively Coupled Plasma - Mass Spectroscopy (ICP-MS)

Inductively Coupled Plasma - Mass Spectroscopy (ICP-MS) is an analytical instrument that works by turning an inert gas, for example argon, into plasma which is achieved by generating an electric spark which is passed through the argon. This causes enough of the argon to lose electrons and become ions for the gas to interact with a fluctuating magnetic field (Jackson and Jackson, 2004). The plasma is confined in a plasma torch and is extremely hot (7000 -10,000K) (Langford *et al,* 2005). In order for the sample to be introduced, a stream of argon gas is passed through the plasma which punches a hole in the centre of the plasma creating the characteristic doughnut or toroidal shape (Langford *et al*, 2005). This stream of argon is cooler than the plasma and is known as the carrier gas as it carriers the sample. The sample is turned into an aerosol and when it comes into contact with the plasma it vaporises and the solid sample breaks down into atoms and ionises. These ions are what get detected on the MS and can be quantified. ICP-MS has become a very useful tool to use and one reason for that is its detection limits. The detection limits in the ppb and sub-ppb levels are commonly achieved with ICP-MS for many of the elements of interest (Lewen *et al,* 2004).

Langford *et al* (2005) agrees with this and says that typical sensitivities for metals by ICP-MS are in the trace (ng $ml^{-1}$) to ultra trace (pg $mL^{-1}$) range. Due to this sensitivity ICP-MS is quite handy to measure Rhenium at lower than several pictogram per millilitre levels (Uchida *et al*, 2005) and this technique has become the most extensive routine analytical technique for the analysis of high-purity rare earth oxides (He *et al*, 2005) and also biological and geological samples (He *et al*, 2005). Şahan *et al* (2007) mentions that owing to the peculiar characteristics of ICP-MS (low detection limits, multi elemental capacity, wide linear range etc) the number of papers dealing with the analysis of food samples by ICP-MS has increased in recent years. Despite ICP-MS being the instrument of choice for many analysis, two main drawbacks to using ICP-MS is spectral and non-spectral interference (matrix effect). Spectral interference occurs when two or more different species have the same nominal mass-to-charge ratio so the signal at the mass cannot be resolved (He *et al*, 2005). Furthermore, ICP-MS performance in analyses of geological materials is commonly affected by interface effects, matrix effects; polyatomic and isobaric interference, signal drift and memory effect (Li *et al*, 2010).

### 1.6.5. Atomic Absorption Spectroscopy (AAS)

Atomic Absorption Spectroscopy is a widely used analytical instrument that is largely used for the determination of metals and semi-metals in food as well as on biological, environmental, geological and other matrices (Bezerra *et al*, 2010). The AAS has two main techniques, the graphite furnace and the flame. The graphite furnace works at lower temperatures than the flame but has a better detection limit. The furnace can detect concentrations down to part per billion, whereas the flame can detect metals at trace levels (0.1 - 100ppm) in a wide range of materials (Fifield and Kealey, 2000). The graphite furnace technique works by inserting a small volume of sample (5 - 100µl) (Langford *et al*, 2005) onto a graphite tube. The sample goes through a heat cycle where it dries and eventually the temperature gets high enough to atomise the sample. With the flame the sample is drawn up a tube and goes through a nebuliser, which, in turn creates an aerosol of the sample which, when it comes into contact with the flame, instantly atomises. The flame is a common technique; however there is a large demand to improve its sensitivity due to some drawbacks in nebulisation efficiency since only 5 - 10% of the primary aerosol reaches the flame (Bezerra *et al*, 2010).

The two types of gas mixtures that can be used for the flame are air-acetylene (reaches temperature of 2500K) and nitrous oxide - acetylene which reaches temperatures of 3150K (Langford *et al*, 2005).

Whether the graphite furnace or the flame is being used, both techniques need a hallow cathode lamp (HCL) to work. These lamps are specific to the element of interest and are coated with the element. This makes the instrument very element specific which means that complex mixtures can be analysed without the need to separate them first (Jackson and Jackson, 2004). The HCL emits radiation at a specific wavelength to the element of interest and passes through the graphite tube or flame where the sample atomises. The radiation from the lamp excites the sample, moving them to a higher energy level. This absorption of energy from the lamp to the sample is what gets detected. The more concentrated a sample, the more radiation of the lamp will be absorbed by the sample and so less radiation from the lamp will get detected. Running known concentrations of the sample of interest first means a calibration graph can be produced which can then be used to quantify the samples.

## 2. Materials and Methods

### 2.1. Reagents and equipment

All the solid metals (Nickel, Molybdenum, Cobalt, Chromium, Tantalum, Hafnium, Tungsten, Titanium, Aluminium, and Rhenium) were bought from ebay and were verified by use of XRF.

The Nitric Acid (70%) and Hydrochloric Acid (37%) were from Fisher Scientific, along with the chloroform (HPLC grade) which was used in the molecular imprinted polymer (MIP) process. The Ethyleneglycoldimethacrylate (EGDMA); 4 Vinylpyridine (4VP); and 1,1' azobis(cycloheaxanecarbonitirile) (ACBN), along with ≥99% Ammonium Perrhenate and ≥99% Potassium Perrhenate, were all obtained from Sigma-Aldrich and were used in the MIP process. The sodium hydroxide was already purchased and came in a solid pellet form, which was used to bring acidic solutions to neutral.

All the metal standards were Atomic Absorption Spectroscopy (AAS) grade solutions and all had a concentration of 1000ppm. The metals were dissolved in solution as follows: Tantalum and Hafnium were dissolved in 5% Hydrofluoric Acid (HF). Molybdenum and Tungsten were dissolved in 0.1M ammonia. Titanium was dissolved in 2M Hydrochloric Acid (HCl). Ammonium Perrhenate was dissolved in water. Cobalt, aluminium, chromium, and nickel were all dissolved in 1M Nitric Acid. These standards were used in the AAS and for experiment four.

Analytical balances were used when any weighing was carried to ensure accuracy.

During the polymerisation process an oven was used at a specific temperature of 70°C which was monitored.

All samples were analysed using either the Atomic Absorption Spectrometer (AAS); Fourier Transform Infrared Spectrometer (FTIR); X-ray Fluorescence (XRF) or a combination of the above. The AAS was a Perkin Elmer AAnalyst 800 with an AS 800 auto sampler. There was the option to use either a flame burner head or a graphite furnace. The FTIR was a Perkin Elmer Spectrum 100 FTIR Spectrometer. The XRF was a portable Thermo Scientific Niton XL2 XRF Analyzer GOLDD; however this later changed to the Thermo Scientific Niton XL3t XRF Analyzer.

## 2.2. Dissolution of Individual metals in Aqua Regia

### 2.2.1. Preparation - using magnetic stirrers

Aqua regia consisting of Nitric Acid ($HNO_3$) and Hydrochloric Acid (HCl), at a ratio of 1:3 respectively was prepared, up to a volume of 300ml, for ten individual metals that are in the super alloy CMSX-4.
The metals used were: Cobalt (Co); Nickel (Ni); Tungsten (W); Chromium (Cr); Molybdenum (Mo); Tantalum (Ta); Aluminium (Al); Titanium (Ti); Hafnium (Hf); Rhenium (Re).

To see if the metals would dissolve in different strengths of aqua regia, three aqua regia solutions were prepared: one solution of pure aqua regia; the other two diluted with different amounts of deionised water (the deionised water was between 15.5 - 18.2 ΩM) whilst keeping the acid ratio's at 1:3 $HNO_3$ and HCl respectively.

Table 2 - volumes used to create the 300ml solutions of aqua regia

| Acid Percentage (%) | Nitric Acid (ml) | Acid Percentage (%) | Hydrochloric Acid (ml) | Deionised Water (ml) |
|---|---|---|---|---|
| 23.3 | 100 | 24.6 | 200 | 0 |
| 14.15 | 60.73 | 14.96 | 121.63 | 117.64 |
| 5 | 21.45 | 5.2 | 42.2 | 236.35 |

A three plate magnetic stirrer was placed into a fume cupboard and a 400ml glass beaker was placed on each of the three plates. Each beaker was labelled with the following: $NHO_3$ percentage to be used (23.3, 14.15, 5% respectively); the name of the metal being dissolved; date; and corrosive sticker. A plastic magnetic spinner and glass thermometer was placed into each empty beaker.
One metal was analysed at a time and so three pieces of the same metal were needed. The three pieces of metal being analysed were weighed using an analytical balance for precision and the weight was recorded.
The aqua regia solutions were prepared fresh for each of the ten different metals. The deionised water was measured out first using a glass measuring cylinder, up to the nearest even number (as the cylinder went up in even increments), this was then poured into the corresponding beakers. The volume of water was then topped up to the desired amount

using an automated pipette for accuracy. For example, 14.15% $HNO_3$ solution: 117.64ml of water was needed in total so 116ml water was measured using the measuring cylinder and 1.64ml was measured using an automated pipette.

Using the same method, the different volumes of HCl were measured and poured extremely slowly into the corresponding beakers. Caution was needed as an exothermic reaction took place when the acid came into contact with the deionised water.

Finally $HNO_3$ was measured using the same procedure and again was poured into the beakers very slowly due to the exothermic reactions.

The metal being used was then placed carefully into each beaker and a glass dish was placed on top of each beaker and then the magnetic stirrer plate was turned on. This was to ensure the solutions were constantly mixed during the duration of the experiment.

The picture below (Fig.2) shows how the experiment was set up.


Fig.2 - Set up of experiment one

The three pieces of the metal being analysed were placed into each beaker and the temperature of each solution was recorded.

The experiment was carried out for seven days to determine the efficiency of aqua regia over a prolonged time. During the seven days, samples were taken at regular intervals. The intervals at which the samples were taken depended on which day the experiment started, so the samples were taken as follows:

Day 1 - Six samples taken at 1 hour intervals

Day 2 - Four samples taken at 2.5 hour intervals

Day 3 - Three samples taken at 3.5 hour intervals

Day 4 - Two samples taken at a 7 hour interval with a third sample being taken 10.5 hours after the first Day 4 sample was taken

Day 5 - Two samples taken at a 7 hours interval

Day 6 and 7 - No sample taken

Day 8 - One sample taken 168 hours from Day 1 start time

Day 1 - Six samples taken at 1 hour intervals

Day 2 - Four samples taken at 2.5 hour intervals

Day 3 - Three samples taken at 3.5 hour intervals

Day 4 - Two samples taken at a 7 hour interval with a third sample being taken 10.5 hours after the first Day 4 sample was taken

Day 5 and 6 - No sample taken

Day 7 - Two samples taken at a 7 hour interval

Day 8 - One sample taken 168 hours from Day 1 start time

At each interval, 100µl samples were taken from each beaker using an automated pipette and was placed into a 100ml volumetric flask. The volumetric flask was then filled up with deionised water until just below the fill line. Using a glass pipette the last drops of deionised water were added to the volumetric flask until the bottom of the meniscus was touching the 100ml fill line.

The volumetric flask was then vortexed for 20 seconds to produce a homogenous solution, which was then poured into a plastic 100ml screw top bottle. The bottles were labelled and placed to one side ready for analysis on the Atomic Absorption Spectroscopy (AAS).

If any of the samples were too concentrated for the AAS then they were diluted further. 1ml from the original diluted sample was pipetted into a 100ml volumetric flask using an automated pipette. This was then filled to the line with deionised water, vortexed for 20 seconds and then poured into a new plastic bottle, labelled, and was re-run on the AAS.

The temperature from each beaker was also recorded at the same time as when the samples were taken.

Observations of the solutions and metals were noted when the temperature was taken, colour/appearance of the solution and appearance of the metal were the two criteria being observed.

At the end of the experiment the pieces of metals (if still remaining) were removed from the beakers and left to dry and were then weighed again using analytical scales to calculate the total amount of metal dissolved.

### 2.2.2. Rhenium metal in Aqua Regia preparation - using magnetic stirrers and Ultra Sonic bath

The use of an ultra sonic bath was chosen to see if it would help accelerate the dissolution rate of metals in aqua regia solution. Rhenium was the metal that was tested in this experiment.
The same procedures that were used in the 'Individual metals in Aqua Regia preparation - using magnetic stirrers' (Page 32) experiment were used for this experiment for the preparation of the aqua regia solutions. Only the two diluted concentrations of aqua regia, 14.15% and 5% were created.

The magnetic stirrer plate and ultra sonic bath were both placed in a fume cupboard. The magnetic spinner and glass thermometer was placed into the two 400ml glass beakers and once the two aqua regia solutions were made, the weighed piece of rhenium was then carefully placed into solution. The temperature was recorded once the metal was placed into the solution.

Samples were taken at set intervals as follows:
Day 1 - Six samples taken at 1 hour intervals
Day 2 - Four samples taken at 2.5 hour intervals
Day 3 - Three samples taken at 3.5 hour intervals
Day 4 - Two samples taken at a 7 hour interval with a third sample being taken 10.5 hours after the first Day 4 sample was taken
Day 5 and 6 - No sample taken
Day 7 - Two samples taken at a 7 hour interval
Day 8 - One sample taken 168 hours from Day 1 start time

The temperature was only recorded twice everyday (except on day 5 and 6), once in the morning and once in the evening.

The ultra sonic bath was also used in this experiment and was used for 20 minutes at a time. The ultra sonic bath was filled up with water and when it was time for the bath to be used the glass beakers were taken off the magnetic stirrer and placed carefully into the ultra sonic bath. The bath was then switched on and a timer was set for 20 minutes. Once the 20 minutes was up the beakers were removed from the ultra sonic bath, dried quickly and then replaced back onto the magnetic stirrer.

The beakers were placed into the ultra sonic bath 20 minutes before samples were needed to be taken, with the exception of Day 7 where two samples were taken but the ultra sonic bath was used three times (halfway through the seven hour interval).

The amount of time the beakers spent in the ultra sonic bath are as follows:

Day 1 - Six times for 20 minutes = 2 hours total

Day 2 - Four times for 20 minutes = 1 hours 20 minutes total

Day 3 - Three times for 20 minutes = 1 hour total

Day 4 - Three times for 20 minutes = 1 hour total

Day 5 and 6 - Not used

Day 7 - Three times for 20 minutes = 1 hour total

Day 8 - One time for 20 minutes = 20 minutes total

The samples had a total of 6 hours 40 minutes in the ultra sonic bath for the duration of the experiment.

When the samples were taken, 100µl samples were taken from each beaker using an automated pipette and were placed into a 100ml volumetric flask. The volumetric flask was then filled up with deionised water until the bottom of the meniscus was touching the fill line. The volumetric flask was then vortexed for 20 seconds to produce a homogenous solution, which was then poured into a plastic 100ml screw top bottle. The bottles were labelled and placed to one side ready for analysis on the Atomic Absorption Spectroscopy (AAS).

Observations of the solution and appearance of the metal was recorded on a daily basis.

## 2.3. Rhenium Molecular Imprinted Polymers

### 2.3.1. Sample preparation

Five molecular imprinted polymers (MIP) were created containing different quantities of rhenium. A blank was also created using the exact same procedure with the exception of having the template introduced into the polymerisation process.

Two different procedures were used in preparing the ammonium perrhenate (which acted as the template) before being added to the polymerisation solution.

Procedure one meant that the ammonium perrhenate was measured out using analytical scales to the desired amount and added straight into a heatproof glass vial (which could eventually be sealed). The second procedure incorporated a dissolution step where the ammonium perrhenate was weighed to the desired amount, using analytical scales and added to a heatproof glass vial. 1ml of deionised water (which was measured using an automated pipette) was then added to the vial and the glass vial was vortexed until the ammonium perrhenate had dissolved.

The specific details are listed in table 3 below.

| **MIP ID** | **Amount of Ammonium Perrhenate used (mg)** | **Dissolved in 1ml Deionised water** |
|---|---|---|
| MIP Test 1 | 188 | No |
| MIP Test 2 | 200 | No |
| MIP Test 3 | 30 | Yes |
| MIP Test 4 | 60 | Yes |
| MIP Test 5 | 120 | Yes |
| MIP Test 6 (blank) | 0 | Yes |

Table 3 - Specific details of amount of Ammonium Perrhenate used and if dissolved in deionised water first

Once the ammonium perrhenate had been added to the glass vial following the procedure above, 0.55ml of 4-vinylpyridine (used as a monomer) was pipetted (using an automated pipette) into the glass vial followed by 6.7ml of chloroform (used as a porogen) which was measured using a glass measuring cylinder and automated pipette.

5.62ml of Ethyleneglycoldimethacrylate (EGDMA) (as the cross linker) was then measured out using a measuring cylinder and automated pipette and was poured into the glass vial, followed by 120mg 1,1'-azobis(cyclohexanecarbonitrile) which was weighed out on analytical scales and was used as a thermal initiator.

Once all the chemicals were added to the glass vial, it was sealed using a rubber bung surrounded by a metal casing (Fig.3a). The sealed vial was then vortexed for one minute. Two thin hallow metal tubes were pushed through the rubber bung, one of the metal tubes was suspended above the solution and the other was pushed inside the solution (Fig.3b). A source of nitrogen was attached to the metal tube that was pushed into the solution (Fig.3c) and the solution was purged with nitrogen for five minutes. The second tube was used to allow the gasses to escape.


Fig.3a - Sealing of solution

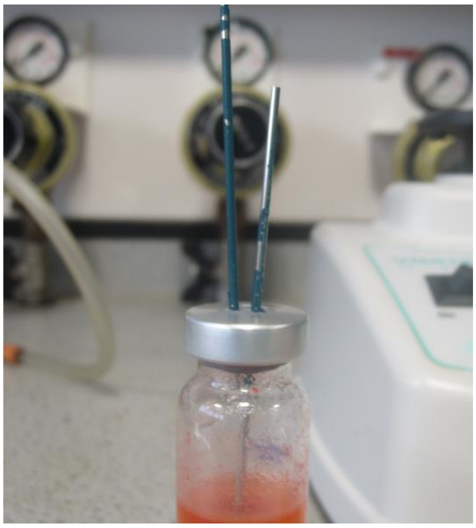


Fig.3b - Configuration of metal tubing

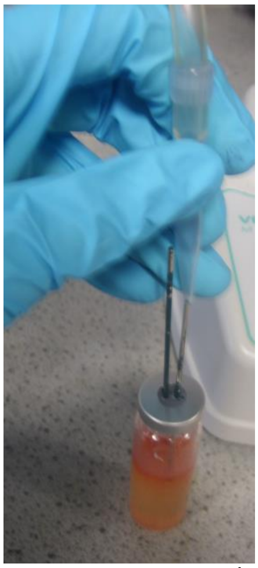


Fig.3c - Nitrogen attachment

Once the solution was purged with nitrogen, the metal tubing that was pushed in the solution was removed, leaving just one. The glass vial was then placed in an oven for 48 hours, at a temperature of 70°C to allow the solution to polymerise (Fig.3d).
The metal tubing was left in the vial to eliminate any build up of pressure from the heated chemicals and so preventing the vial from exploding.

After polymerisation was complete the solid polymer was removed from the glass vial by crushing the polymer into smaller chunks using a glass rod. The smaller chunks of polymer were then poured into a mechanical mortar, a little at a time, and ground until the particle size was homogenous and very fine (like the size of sand) (Fig.3e). A ceramic ball was used inside the mortar to crush the polymer down (Fig.3f).

Fig.3d - MIPs ready for polymerisation

Fig.3e - Crushed up MIP

Fig.3f- MIP in mechanical mortar

Once the MIP was ground up it was poured into a screw top glass vial, labelled and was ready to be used. Each polymerisation solution produced between 6-7g of ground MIP.

**2.3.2. Rhenium Molecular Imprinted Polymer experiment preparation**

2.3.2.1. Assembly of Molecular Imprinted Polymer cartridge

Once the six molecular imprinted polymers (MIP's) were created (five samples and one blank) 1g of each was placed into an old Solid Phase Extraction (SPE) cartridge.

Two cartridges were needed to produce one that could be used for the MIP. One of the two cartridges was sawn in half between the two frits that were holding the silica powder in place. Once sawn in half, the powder was removed and using a glass rod the two frits were removed and put to one side (the cartridge was discarded). The second cartridge needed the top frit removing in order to remove the silica powder without cutting through the cartridge. This was achieved by using a pair of scissors which chopped at the top frit until it broke into little pieces. Using a pair of tweezers the frit pieces were removed and the silica powder discarded.

The cartridge and the two frits were cleaned with deionised water and then left to dry. Once dry, 1g of MIP was weighed using analytical scales and was poured into the cartridge. The frit at the bottom of the cartridge held the polymer in place. Using one of the spare frits, it was pushed into the top of the cartridge and with a glass rod it was pushed down the cartridge until it compacted the 1g of MIP; this prevented the MIP from spilling out of the top of the cartridge. The cartridge was then labelled with the MIP ID and was then ready to be used (Fig.4).

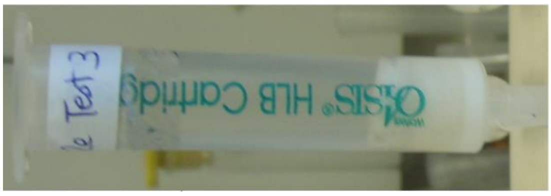


Fig.4 - MIP cartridge assembly

**2.4. Making of Hydrochloric Acid stock solutions**

Hydrochloric Acid (HCl) was used to remove the rhenium from the MIP's. Different Molar concentrations (M) of HCl were created to determine which concentration removed the rhenium from the MIP most effectively.

200ml stock solutions were made at a time and four different concentrations were produced: 1M; 3M; 6M; 8M. To see the volumes used to make the desired concentrations go to appendix 1.

The volumes were measured out in a fume cupboard using a glass measuring cylinder and automated pipette.

The deionised water was measured out first and was poured into a 250ml glass screw top bottle. The HCl was then measured and poured extremely slowly into the glass bottle containing the water. An exothermic reaction took place therefore the screw top lid was left off for 5 minutes while the solution cooled. Once cooled, the lid was screwed tightly on and the bottle was vortexed for 30 seconds to ensure the mixture was homogenous. The bottle was clearly labelled and set aside ready to be used.

**2.5. Rhenium Molecular Imprinted Polymer procedure**

Test MIP 1-4 which contained 188mg, 200mg, 30mg and 60mg of ammonium perrhenate template respectively were placed in the SPE cartridge following the method described on page 39. These were the first to be tested.

Before removing of the template began, the cartridge was scanned using a portable XRF instrument to determine how much rhenium was present. Once scanned, the cartridges were placed on valves which were attached to a vacuum pump. A 20ml glass beaker was placed under each valve, ready to collect the solution passed through the MIP (Fig.5). Each MIP was washed three times with 5ml of deionised water (15ml in total). After the third wash, the cartridges were scanned again using the XRF to determine the presence of rhenium.


Fig.5 - MIP experiment set up

2.5.1. Template removal

The ammonium perrhenate template needed to be removed. This was achieved using different concentrations of hydrochloric acid. Each cartridge had 5ml of HCl eluted through the MIP at a time and each time the 5ml solution was collected in the glass beaker. After each run throughout the experiment the 5ml solution in the glass beaker was poured into a 20ml volumetric flask. The beaker was then rinsed with 5ml deionised water and was also poured into the volumetric flask. The flask was then filled to the line with deionised water. Once filled, the volumetric flask was vortexed for 20seconds and then poured into a glass screw top bottle where it was labelled and stored ready to be analysed on the AAS. Along with collecting the eluted solutions for each cartridge after each run, each cartridge was scanned using the XRF and the results recorded to determine the presence of rhenium in the MIP after each step of the process throughout the experiment. Table 4 shows, how many times each cartridge was eluted with the different concentrations of HCl for the removal of the template. 1M HCl was started with to see how affective it would be at removing the template. This was increased until 8M HCl was used which had the best removal capability.

Table 4 - Volumes used to for template removal

| Hydrochloric Acid (M) | No. of elution's | Total Volume used (ml) |
|---|---|---|
| 1 | 5 | 25 |
| 3 | 8 | 40 |
| 6 | 8 | 40 |
| 8 | 8 | 40 |

### 2.5.2. Analyte addition and removal

Once the template was removed as much as possible, which was indicated by the XRF detecting very low percentages of rhenium, the MIP could be loaded with analyte to see if it would be captured by the MIP.

A concentration of 3000ppm ammonium perrhenate, in 5ml deionised water was used for each cartridge. To get the concentration, 0.015g of ammonium perrhenate was weighed using analytical scales. This was poured into a 5ml volumetric flask which was then topped up with deionised water. The flask was then vortexed for 20 seconds or until all the ammonium perrhenate had dissolved. This was then poured into the cartridge and eluted through just like the HCl was. After the analyte was added, each MIP's were washed with 5ml deionised water three times. Once washed, HCl was used again to try and remove the analyte from the MIP. 6M HCL was used sixteen times (5ml each), using a total of 80ml followed by four elution's with 8M HCl until almost all of the analyte had been removed.

### 2.5.3. Maximum analyte addition and removal

For MIP test 1- 3 the same procedure was followed as above, where 3000ppm ammonium perrhenate analyte was used in 5ml deionised water. This was added to each cartridge and then washed three times with deionised water. This was repeated a further two times. After all the analyte had been added, it needed to be removed using HCl. The 8M HCl was used this time, 5ml at a time, until most of the rhenium had been removed. The process of adding three lots of 3000ppm ammonium perrhenate analyte (with three washes with deionised in between) and then removing the analyte with 8M HCl was carried out another one time. On the third time of trying to load the MIP to the maximum, 10000ppm of ammonium perrhenate was used instead of 3000ppm. 0.050g of ammonium perrhenate was weighed and added to a 5ml volumetric flask where it was filled with deionised water and then vortexed until the ammonium perrhenate had dissolved. This was then added to test 2 - 3 and eluted through. The MIP's were then washed three times with deionised water and then a further 3000ppm of ammonium perrhenate was added, followed by three more washes with deionised water.  8M HCl was then used to remove the analyte from MIP test 2 - 3.

For MIP test 4 (which contained 60mg of ammonium perrhenate template), when the maximum loading of the MIP was carried out, instead of doing three runs with 3000ppm ammonium perrhenate analyte (with three water rinses in between), a total of six runs were carried out until the maximum loading was reached. Once the maximum load was reached, the MIP was rinsed with deionised water three times and then 8M HCl was used to remove the analyte from the MIP.

MIP Test 5, which contained 120mg of ammonium perrhenate, was produced after tests 1-4. The XRF was used after each step and the eluted solutions were collected, as above, ready for analysis with the AAS. After the initial rinse with water, the MIP template was removed with 8M HCl. Once the template was removed, the same procedure that was used for MIP test 4 was used with MIP test 5. Six runs of 3000ppm ammonium perrhenate were loaded into the MIP until maximum loading was achieved. The analyte was then removed using 8M HCl.

A blank MIP (Test 6) was also tested. The XRF was used to determine if any rhenium was present. The blank MIP was rinsed three times with deionised water and then 3000ppm of ammonium perrhenate (in 5ml solution) was eluted through the MIP. The blank was then rinsed again with water three times and the XRF recorded if any rhenium was detected after each step.

**2.6. FTIR analysis of MIP samples**

The FTIR spectrometer was used to try and get an in-depth understanding of the molecular structure of the molecular imprinted polymers.

The FTIR needed to be prepared prior to running samples. Using the software the measurement units were set to absorbance (A) and the number of scans was set to 64. The range was set to 4000 - 450 $cm^{-1}$. The sample window was cleaned using a 50/50% solution of water and methanol. The FTIR ran its first scan with no sample present to scan the background noise. The instrument was then ready to test samples.

MIP Test 3, which contained 30mg of ammonium perrhenate template, was tested first. A small amount was placed onto the FTIR sample window and the clamp was pushed and screwed down to lock the sample in place (Fig.6a and 6b). Once tested, the sample was discarded and the window was cleaned.

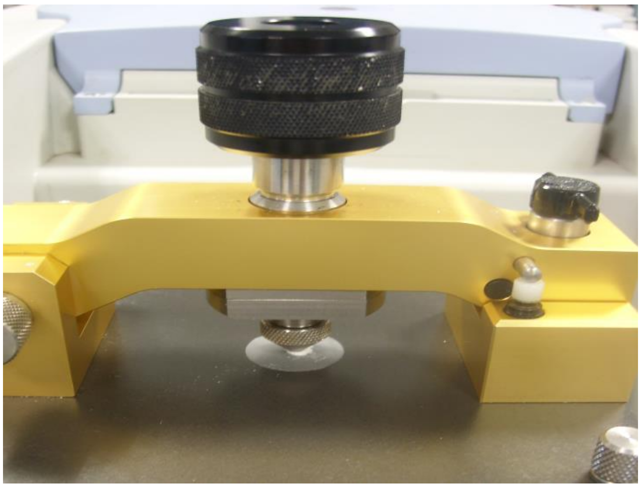


Fig.6a - FTIR sample clamp

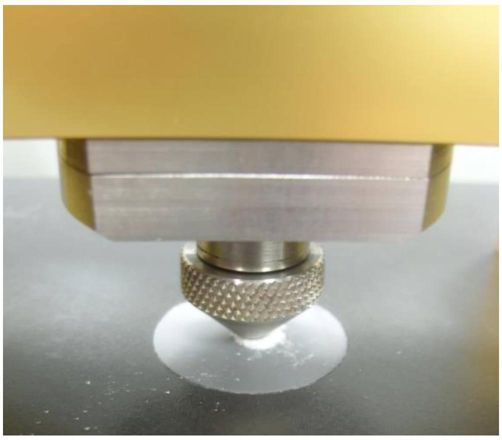


Fig.6b - sample on analysis window

2.6.1. Rinse Stage

1g of test 3 was added into a glass beaker which contained a frit bottom which was attached to a rubber bung (Fig.6c). This could be attached to a conical flask which had a vacuum pump attached. 10ml of deionised water was then poured into the beaker with the MIP. The solution was stirred with a glass rod (Fig.6d) for 10 minutes and once the 10 minutes was over the pump was turned on, and the solution was sucked into the conical flask, leaving the MIP behind. The solution was constantly stirred while the even while the vacuum pump was on. The MIP was left to dry and then a small sample was taken from the beaker and tested on the FTIR.

Fig.6c - MIP in glass beaker with frit

Fig.6d - Stirring of MIP in solution

2.6.2. Template removal stage

Once tested, the MIP was attached back onto the conical flask and 10ml of 8M HCl was added. Again the solution was stirred for 10 minutes before the vacuum pump was turned on to remove the solution. The MIP was left to dry and then a small sample was tested again on the FTIR.

2.6.3. Ammonium perrhenate analyte addition

A 10ml water solution with a concentration of 8000ppm ammonium perrhenate was created by weighing out 0.08g of ammonium perrhenate and adding it to a 10ml volumetric flask which was filled to the line with deionised water. The volumetric flask was the vortexed for 20 seconds until all the ammonium perrhenate had dissolved.

This solution was then added to the MIP in the beaker and was stirred for 10 minutes. After the 10 minutes was up the solution was eluted through using the vacuum pump. The MIP was left to dry and then a small sample was taken to be tested on the FTIR.

#### 2.6.4. Analyte removal stage

To remove the 8000ppm ammonium perrhenate analyte, 8M HCl was used. 10ml was measured out and poured into the beaker with the MIP sample. This was stirred for 10minutes and then the solution was eluted through. The MIP was left to dry and was then tested in the FTIR.

#### 2.6.5. Potassium perrhenate analyte addition

A new 1g sample of MIP test 3 was weighed and placed into a glass beaker with the frit bottom. The same procedure was followed as above, however, instead of adding 8000ppm of ammonium perrhenate, 8000ppm of potassium perrhenate was used instead. 0.0862g of potassium perrhenate was weighed (to give the same concentration as ammonium perrhenate) and added to a 10ml volumetric flask. The flask was filled to the line with deionised water and vortexed until all was dissolved.

Two lots of 1g samples were weighed out for the MIP test 4 (which contained 60mg of ammonium perrhenate template). The same procedure was carried out as above, however instead of using 8000ppm of ammonium and potassium perrhenate, 10,000ppm was used. 0.1g of ammonium perrhenate was weighed and added to a 10ml volumetric flask where it was filled and vortexed. 0.108g of potassium perrhenate was weighed to get a concentration of 10,000ppm.

A blank MIP was tested in the FTIR to see if the spectra would have any differences to MIP samples which contain templates.

Pure ammonium perrhenate and pure potassium perrhenate (≥99%) were analysed on the FTIR to identify the difference between the two and to locate the perrhenate peak which was the peak of interest for when the samples were tested.

**2.7. Preliminary MIP metal selectivity method**

To see if the produced molecular imprinted polymer (MIP Test 4 (60mg template)) was selective to ammonium perrhenate in the presence of other metals the following procedure was carried out to examine this theory. 1g of MIP test 4 was weighed and added to a SPE cartridge, following the same procedure as page 39. The template was removed as much as possible and each step was analysed using the XRF.

The 1000mg/L AAS standard solutions were used in this experiment for the following metals: molybdenum; cobalt; chromium; aluminium; nickel and tungsten. For the rhenium, ammonium perrhenate was used at a concentration of 1000mg/L.

Tantalum, Hafnium and Titanium were not used in this experiment.

2ml of each metal was measured out in a measuring cylinder and poured into a glass beaker. For the ammonium perrhenate, 0.002g was weighed out added to 2ml of deionised water. The solution was vortexed to dissolve the ammonium perrhenate. This gave a concentration of 1000mg/L ammonium perrhenate and this was added to the other metal standards. There was a total of 14ml solution with all the seven metals; therefore, the concentration of each metal was 125mg/L. To see the calculations go to appendix 2a.

The pH of the solution was pH1, this needed to be changed to neutral (pH7) as this was the pH used when the analyte was added to the MIPs in experiment two and three. To achieve a neutral pH sodium hydroxide (alkali) was used. The sodium hydroxide was in pellets and each pellet weighed on average 0.362g. A pellet was added one at a time until completely dissolved and once no more dissolved no more was added. Twenty one pellets (around 7g) of sodium hydroxide were dissolved in 10ml of deionised water. The sodium hydroxide had a pH of 14.

The beaker with the metal standards was placed into an ice bath and then the sodium hydroxide was added to the solution, one drop at a time until the solution became neutral.

After each drop the pH was checked with pH paper. 0.8ml of sodium hydroxide (27 drops) was added to the solution to make it neutral.
It was extremely important to do this in a fume cupboard and in an ice bath as there very exothermic reaction took place.

Once the metal solution was neutral, filter paper was placed over a glass beaker and the solution was filtered through. Once the solution had passed through the filter paper was kept to one side, ready to be analysed by XRF to see what precipitate had been captured and the filtered metal solution was split into two 5ml samples.
The first 5ml solution was added to the MIP cartridge and the solution was eluted through (using a vacuum pump). The cartridge was then analysed using XRF and then the second 5ml solution was eluted through. Three washes with deionised water followed by analyte removal using 8M HCl followed next.

The second part to this experiment was to see the selectivity of the MIP test 4 when there was no ammonium perrhenate present in the analyte solution. The same procedure as above was used with a few differences.

A new MIP with the 60mg template was used and 1g was weighed out and added to a SPE cartridge. The template was then removed.
Instead of using 2ml of each metal, 4ml was used this time. That gave a concentration of 159.36mg/L for each metal in solution. To see the calculations, go to appendix 2b.
There was a total of 24ml of metal solution. The metal solution was changed to neutral but this time 1.1ml (37 drops) of sodium hydroxide was used to achieve a pH 7.
The solution was filtered and then instead of using only two 5ml solutions in the MIP, four 5ml solutions were used.

The XRF was used after each step during the experiment to record what metals were being detected in the MIP.

**2.8. Making of the Standards**

Standards of different concentrations of each metal being analysed on the AAS was needed to be produced so than they could be analysed on the AAS and produce a calibration graph. The calibration graph would be used to quantify the metal samples run on the AAS.

The nickel and titanium metals, which were run on the graphite furnace of the AAS, needed the standards to have a concentration in µg/L (ppb) range. The standards used for the nickel and titanium were: 20, 40, 60, 80 and 100 µg/L.

To create these concentrations the nickel standard solution, which was of a concentration of 1000mg/L had 100µl pipetted from it and this was added to a 100ml volumetric flask. The volumetric flask was then filled to the line with deionised water. The solution was vortexed to ensure the solution was homogenised and then it was poured into a plastic bottle where it could be stored. This dilution meant that the 1000mg/L standard solution was now 1mg/L. The same was done for the titanium standard solution.

To get the desired concentrations for nickel and titanium the 1mg/L stock solution was used.

To get the 100µg/L concentration, 10ml of the 1mg/L stock solution was measured out and poured into a 100ml volumetric flask. The flask was then filled to the line with deionised water, vortexed and then poured into a plastic bottle for storage. The same procedure was used for the other concentrations but less of the stock solution was used. For the 80; 60; 40; 20µg/L, 8; 6; 4; 2ml of 1mg/L stock solution was used and added to the 100ml volumetric flask.

For chromium, cobalt, tungsten and rhenium, the concentrations of the standards needed to be in the range of mg/L. For this reason, the 1000mg/L standard solution of the metals was used to create the desired concentrations without having to make a 1mg/L stock solution first.

For chromium the concentrations of 0.5; 1; 2; 4mg/L was needed for the first calibration graph. To achieve these concentrations 10µl; 20µl; 40µl and 80µl of the 1000mg/L standard solution was pipetted into a 20ml volumetric flask which was then filled with deionised water. The standards were then vortexed and stored ready for use. The second calibration graph needed standards of 20; 30; 40 and 50mg/L. These were achieved by taking 400µl;

600µl; 800µl and 1ml respectively of the 1000mg/L standard solution and pipetted into a 20ml volumetric flask which was then filled with deionised water.

The same procedure was used for the other metals, where the desired volume of standard solution (1000mg/L) was pipetted into a 20ml volumetric flask, which was the filled to the line with deionised water and the vortexed and stored ready for use.

Cobalt needed two calibration graphs. The first calibration graph used 3; 5; 7 and 9mg/L so to get the desired concentration, 60µl; 100µl; 140µl and 180µl respectively was pipetted into 20ml volumetric flasks. For the second calibration, 10; 50; 100 and 150mg/L was used, therefore, 200µl; 1ml; 3ml and 5ml respectively was pipetted into a 20ml volumetric flask to achieve those concentrations.

Tungsten used 5; 50; 250 and 450mg/L as the calibration standards. 100µl; 1ml; 5ml and 9ml of tungsten standard solution was pipetted into a 20ml volumetric flask, filled with deionised water, vortexed and stored ready for use.

Rhenium used 50; 250; 650 and 1000mg/L standards to produce a calibration graph. To get these concentrations, 1ml; 5ml; 13ml and 20ml of the rhenium standard solution was measured and poured into a 20ml volumetric flask.

**2.9. XRF Analysis**

All the molecular imprinted polymers that were in SPE cartridges were analysed using the XRF. The MIP cartridge was laid flat on a workbench and the circular window of the XRF was manoeuvred so that the window covered the MIP in between the two frits. The circular window was where the source of photons came from to excite the sample and in turn emit x-rays into the same window where a detector picked them up, producing a reading in percentage.

The XRF sample type was set to soils and minerals and then in the soils and minerals option the mining Ta/Hf setting was chosen. The XRF had a cooling down period before it could be used. Once cool and the name of the sample ID was inserted onto the screen, the sample could be tested. This involved holding the XRF onto the sample as mentioned above and the trigger being held for 30 seconds while the sample was being bombarded with x-rays. After 30 seconds the XRF produced the results of all elements detected.

## 2.10. Atomic Absorption Spectroscopy Analysis

All the liquid samples from experiment one and experiment two which were prepared and collected were ready to be analysed on the AAS.

Depending on the metal being analysed depended on whether or not the graphic furnace setting or flame setting was used.

### 2.10.1. Furnace settings

The nickel and titanium used the graphite furnace setting. Once the furnace had been aligned and the lamp that corresponded to the element being analysed was inserted into the AAS it was ready for the samples.

All samples, including blanks and standards (for calibration graph) were poured into individual single use plastic vials. The vials were placed in the auto sampler and each slot in the auto sample had a corresponding number. This number was the location for that individual sample. The location and ID of each sample was inserted into the computer software. The gas that was being used was air and argon. Once started, the auto sampler tip went through each sample, injecting 20µl of sample into the graphic furnace one at a time and the results were recorded. Results were measured in µg/L.

The operational furnace settings for the nickel and titanium were taken from the recommended conditions from the AAS computer software. The settings were as follows:

Element: Titanium.

Spectrometer: Wavelength (nm) - 364.3; Slit Width (nm) - 0.2L

Signal: Type - AA - BG; Measurement - Peak Area (AA); Smoothing (points) - none

<u>Furnace Program</u>

| Temp°C | Ramp Time | Hold Time | Internal Flow | Gas Type |
|---|---|---|---|---|
| 110 | 1 | 30 | 250 | normal |
| 130 | 15 | 30 | 250 | normal |
| 1500 | 10 | 20 | 250 | normal |
| 2500 | 0 | 5 | 0 | normal |
| 2450 | 1 | 3 | 250 | normal |

Element: Nickel

Spectrometer: Wavelength (nm) - 232.0; Slit Width (nm) - 0.2L

Signal: Type - AA - BG; Measurement - Peak Area (AA); Smoothing (points) - none

Furnace Program

| Temp°C | Ramp Time | Hold Time | Internal Flow | Gas Type |
|---|---|---|---|---|
| 110 | 1 | 30 | 250 | normal |
| 130 | 15 | 30 | 250 | normal |
| 1100 | 10 | 20 | 250 | normal |
| 2300 | 0 | 5 | 0 | normal |
| 2450 | 1 | 3 | 250 | normal |

### 2.10.2. Flame settings

Depending on the metal being analysed, either the air/acetylene blue flame was used, or the nitrous oxide/acetylene red flame was used. If the air/acetylene was used then the 10cm burner head had to be attached. If the nitrous oxide/acetylene was used, then the 5cm burner head was used.

The burner head had to be aligned before any new element was used. Once aligned, the samples had to be manually held in place while the flame drew the sample up through the tubing, through the nebulizer and into the flame. All samples ID were inserted into the computer software so results could be kept track of and all results were measured in mg/L. Cobalt and chromium used the air/acetylene flame and Rhenium and Tungsten used the Nitrous oxide/acetylene flame. Aluminium; hafnium; molybdenum and tantalum would have used the nitrous oxide/acetylene flame but they were not analysed.

The operational flame settings were taken from the recommended conditions from the AAS computer software, with the exception of the acetylene flow for the rhenium and titanium which was changed from 7L/min down to 6.8L/min. The flame settings were as follows:

Element: Cobalt

Spectrometer: Wavelength (nm) - 240.7; Slit Width (nm) - 0.2

Signal: Type - AA; Measurement - Time Average

Program: 5 sec holding time; Replica - 3

Flame: Air/Acetylene; Air Flow: 17.0L/min; Acetylene Flow: 3.5L/min

Element: Chromium

Spectrometer: Wavelength (nm) - 357.9; Slit Width (nm) - 0.7

Signal: Type - AA; Measurement - Time Average

Program: 5 sec holding time; Replica - 3

Flame: Air/Acetylene; Air Flow: 17.0L/min; Acetylene Flow: 3.5L/min

Element: Tungsten

Spectrometer: Wavelength (nm) - 255.1; Slit Width (nm) - 0.2

Signal: Type - AA; Measurement - Time Average

Program: 5 sec holding time; Replica: 3

Flame: Nitrous oxide/Acetylene; Nitrous oxide Flow: 16.0L/min; Acetylene Flow: 6.8L/min

Element: Rhenium

Spectrometer: Wavelength (nm) - 346.0; Slit Width (nm) - 0.2

Signal: Type - AA; Measurement - Time Average

Program: 7 sec holding time; Replica - 3

Flame: Nitrous oxide/Acetylene; Nitrous oxide Flow: 16.0L/min; Acetylene Flow: 6.8L/min

# 3. Results

## 3.1. Dissolution of Individual metals in Aqua Regia

Three different strengths of aqua regia were produced each time, for the eleven metals (ten individual and one piece of super alloy) that were to be tested. The three strengths of aqua regia were 5%, 14.15% and 23.3%. When talking about these three percentages in the results, they relate to the percentage of Nitric Acid that is in the solution (but still using the 3:1 ratio of Hydrochloric Acid and Nitric Acid).

The super alloy was only tested in the 23.3% strength aqua regia, the rhenium samples were only tested in the 5% and 14.15% strength aqua regia.

### 3.1.1. Metal - Nickel

3.1.1.1. Observations

Table 5a - 5% Aqua Regia Observations for Nickel

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | dull colour |
| 2 | no change | debris at bottom of beaker |
| 3 | no change | debris dissipated, small holes formed (fig.7a) |
| 4 | no change | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | no change |
| 8 | pale green | brighter colour (fig.7b) |

Table 5b - 14.15% Aqua Regia Observations for Nickel

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | pale green/yellow | bubbles coming off metal |
| 2 | light green | small holes formed |
| 3 | no change | holes increased in size |
| 4 | more intense green | deep circular hole formed (fig.7c) |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | circular hole deepened, holes increase in size |
| 8 | dark green | no change |

Table 5c - 23.3% Aqua Regia Observations for Nickel

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | brown, changed to dark green | very reactive, vigorous bubbles coming off metal. Half the size by end of day 1 |
| 2 | very dark green | no more bubbles, decreased in size |
| 3 | no change | no change |
| 4 | dark green (almost black looking) | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | decreased in size (fig.7d) |
| 8 | no change | no change |


Fig.7a - Nickel from 5% aqua regia


Fig.7b - Shiny Nickel from 5% aqua regia


Fig.7c - Nickel from 14.15% aqua regia

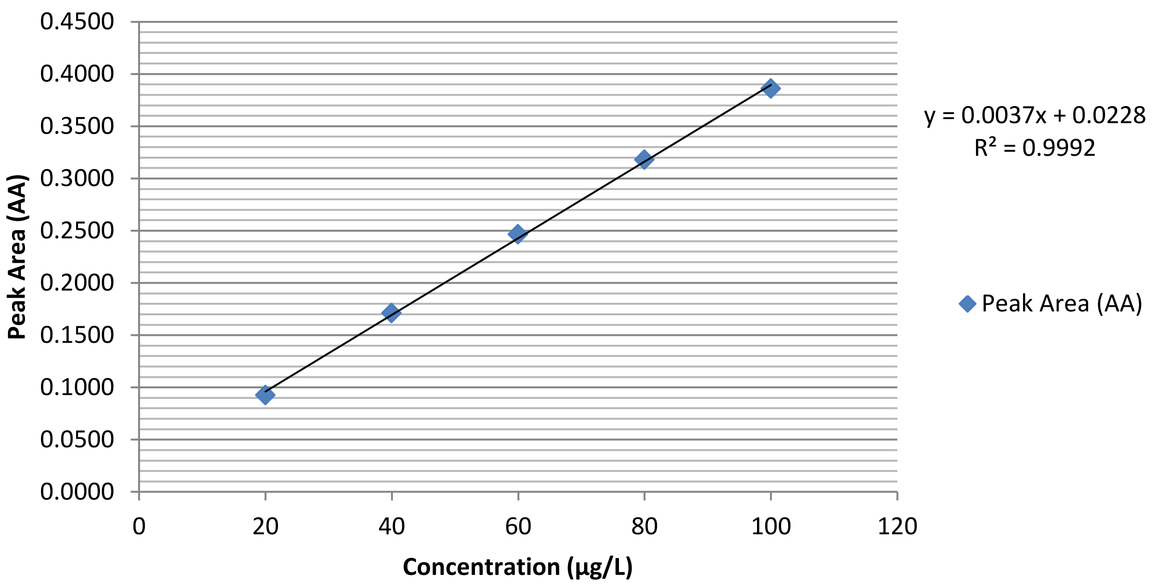

Fig.7d - Nickel from 23.3% aqua regia

#### 3.1.1.2. Analytical Analysis

The nickel standards of known concentrations were used to obtained peak area so that a calibration graph could be obtained. Table 6 shows the concentrations and the average peak areas obtained by the AAS. Fig.8.1 shows the created calibration graph. To look at the raw calibration data go to appendix 3a.

Table 6 - Peak Areas against known concentrations

| Concentration (µg/L) | Peak Area (AA) |
|---|---|
| 20 | 0.0926 |
| 40 | 0.1712 |
| 60 | 0.2465 |
| 80 | 0.3178 |
| 100 | 0.3859 |




The calibration graph has an extremely good positive linear regression as the $R^2$ value is 0.9992 which is extremely close to the value of 1 which would indicate that the known concentrations fit exactly onto the line of the graph.

By using the equation y = 0.0037x + 0.0228 which is produced from the calibration graph, it was possible to calculate the concentrations of the dissolved nickel in the aqua regia solution. The equation needed to be re-arranged to make 'x' the subject in order to work out the concentrations.

The equation was re-arranged as follows:

$$x = \frac{(y - 0.0228)}{0.0037}$$

Where y = peak area of the dissolved nickel in aqua regia, x = concentration in µg/L

The samples needed to be converted from µg/L into mg/L so the 'x' value was divided by 1000. Furthermore the nickel samples were diluted by a dilution factor of 100,000 and so to calculate the original concentration, all the samples were multiplied by 100,000.

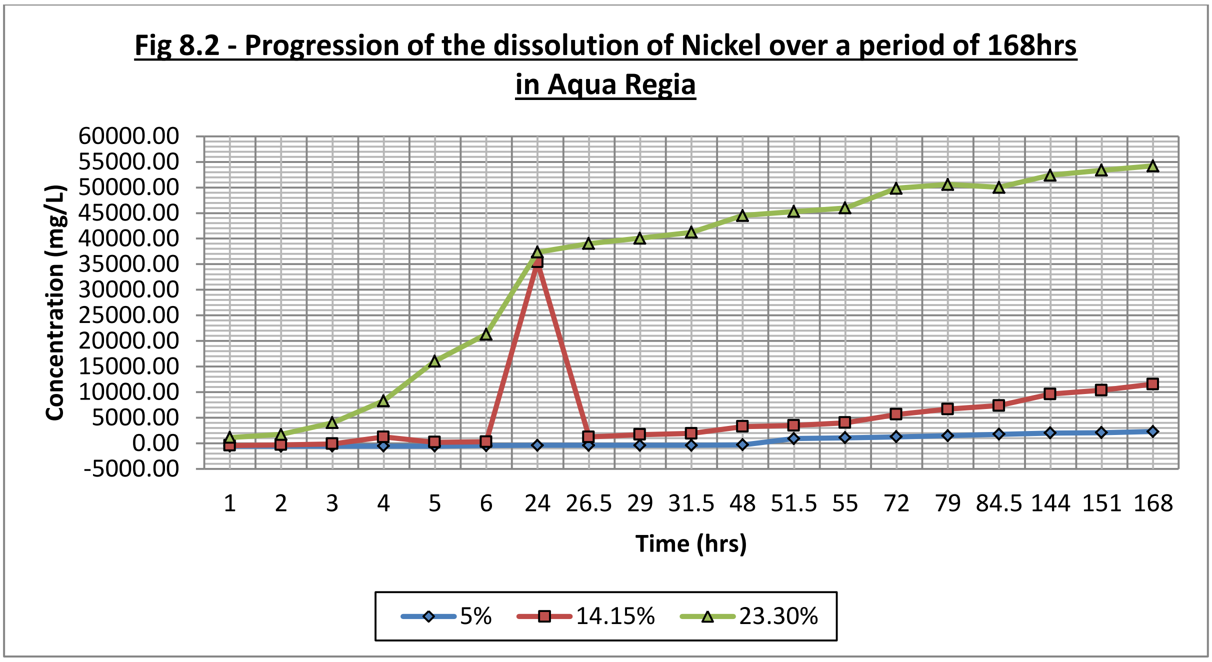



Fig.8.2 shows that the 5% aqua regia solution barely increases during the 168 hour period with the concentration of nickel in solution reaching 2301.80mg/L after 168 hours.
The 14.15% aqua regia solution does not seem to increase much until 55 hours into the experiment where after this time there is a slow but steady dissolution rate with the increase in the concentration of nickel in solution. The 14.15% aqua regia does have an anomaly 24 hours into the experiment where the concentration of nickel increases dramatically from 293.69mg/L 6 hours into the experiment to 35427.03mg/L at 24 hours, where is processed to decreased dramatically down to 1224.32mg/L 2.5 hours later (26.5hrs). The anomalies could be due to analyst error, where the 23.3% aqua regia sample was analysed instead of the 14.25% sample. This is indicated by the fact that both the 14.15% and 23.3% sample at 24 hours has an extremely similar concentration.
The most concentration aqua regia solution, 23.3% has a high dissolution rate over the first 24 hours of the experiment, increasing from 1135.59mg/L 1 hour in, to 37339.64mg/L 24 hours later. After this point the rate of dissolution of nickel seems to slow down and it took 144 hours to dissolve 16863.97mg/L more nickel with the final concentration of nickel in solution being 54203.61mg/L.
To look at the raw AAS data go to appendix 3b.

### 3.1.1.3. Statistical Analysis

The specific samples that were run more than once on the AAS; were run in order to use them for statistical analysis which were inputted into the statgraphic software. The statgraphic plus, version 2.1, used a 3-level factional design to study two factors (time and aqua regia strength) to generate a response, in this case, concentration. The software used a response surface to locate an optimal value.

The samples were converted into mg/L and the averages were used. Table 7 shows the concentrations of the samples.

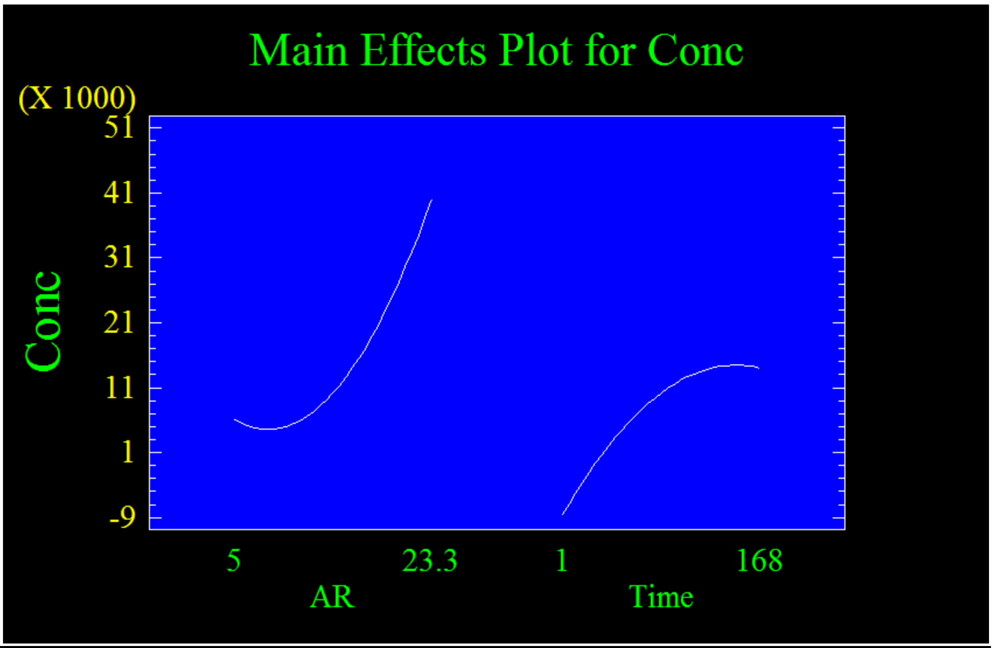
Table 7 - Concentrations of samples used in statgraphic software

| | 5% Aqua Regia | 14.15% Aqua Regia | 23.3% Aqua Regia |
|---|---|---|---|
| Time (hrs) | Concentration (mg/L) | | |
| 1 | -536.04 | -414.41 | 1113.51 |
| 1 (replica) | -545.95 | -419.82 | 1157.66 |
| 84.5 | 1727.93 | 7213.51 | 48711.71 |
| 84.5 (replica) | 1814.41 | 7399.10 | 51335.14 |
| 84.5 (replica) | - | 7460.36 | - |
| 84.5 (replica) | - | 7393.69 | - |
| 168 | 2239.64 | 11547.75 | 54307.21 |
| 168 (replica) | 2363.96 | 11538.74 | 54100.00 |

The values in table 6 were inserted into the statgraphic software and different statistical graphs were generated.

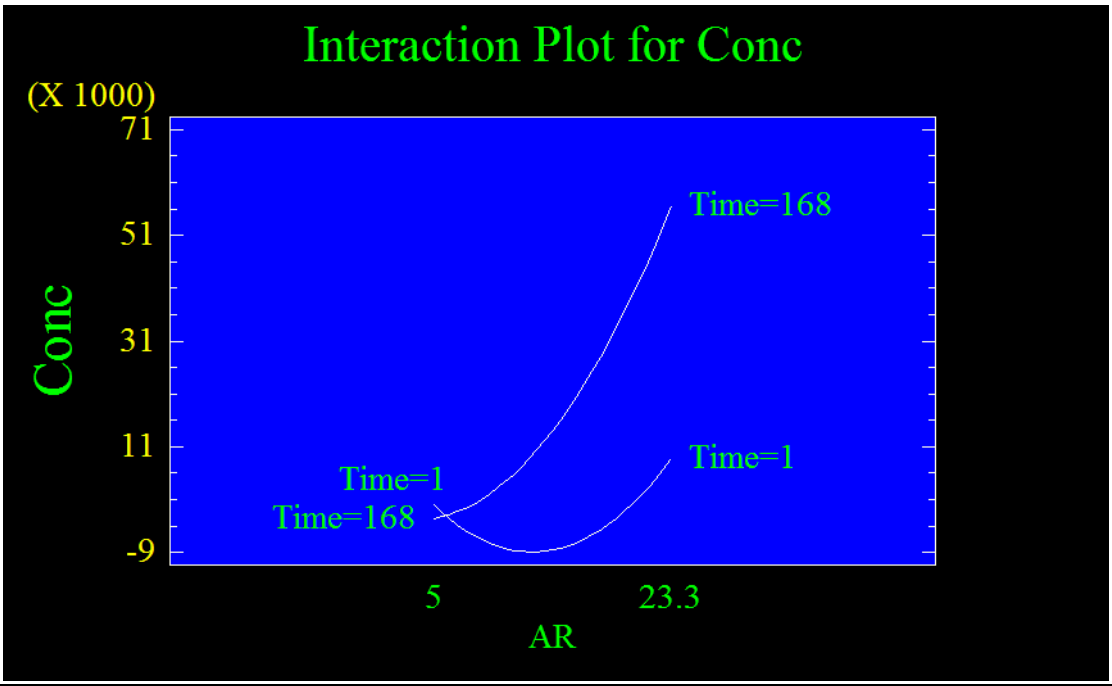
The main effects plot for the concentration of nickel (Fig.8.3) shows that using 5% aqua regia (AR) only around 7000mg/L of nickel would be dissolved. As the concentration of aqua regia increases to 23.3% the amount of nickel being dissolved increased dramatically up to 41000mg/L. Fig.7.3 also indicates that time has the most effect in the dissolution rate of nickel from the start of the experiment to around half way through (84 hours), with the effectiveness of time on the dissolution rate slowing and ending up in a plateau.

Fig.8.3 - Main Effects Plot for Concentration of Nickel




Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

Fig.8.4 - Interaction Plot for Concentration of Nickel

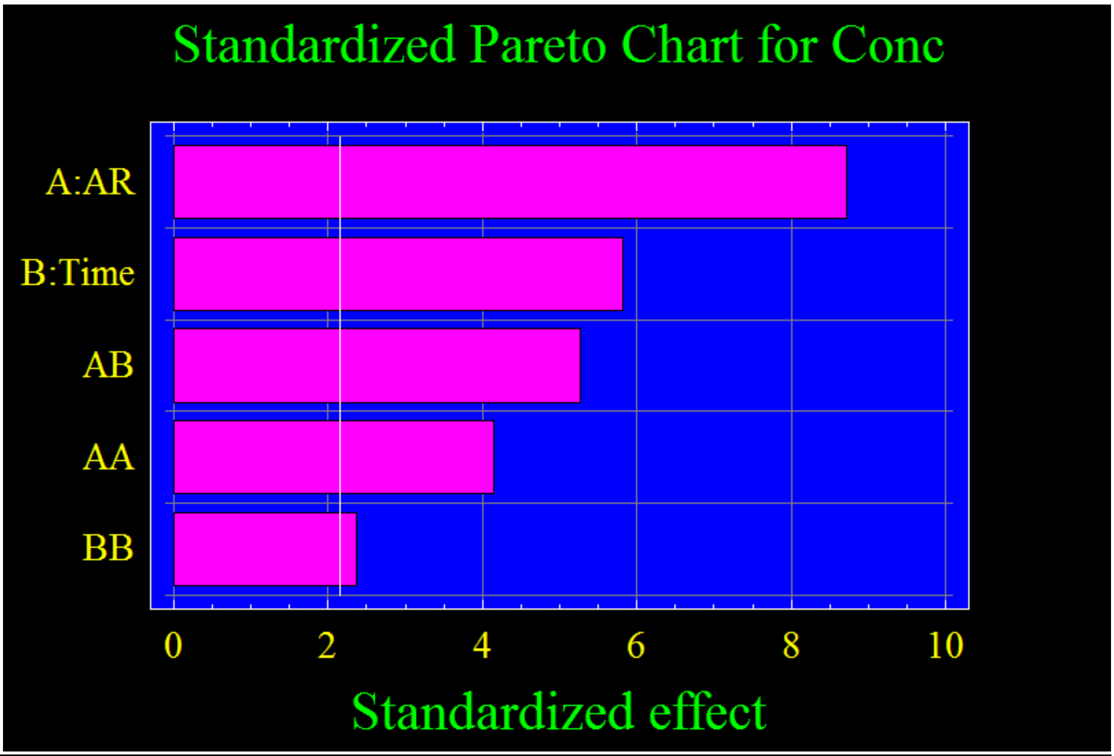



Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The interaction plot for the concentration of nickel (Fig.8.4) indicated that at 5% aqua regia (AR), the concentration of nickel in solution will not change much between 1 and 168 hours, with both points having a concentration of around 1000mg/L. As the concentration of the aqua regia increases, the amount of nickel being dissolved in the first hour decreases, but then starts to increase again as you reach 23.3% aqua regia. The length of time the nickel is in solution becomes more significant for the dissolution rate, the higher the concentration of aqua regia is, as after 168 hours, over 51000mg/L of nickel could be dissolved with 23.3% aqua regia.

The standardized pareto chart for the Concentration of nickel (Fig.8.5) indicates the significance of the different variables, depending on how far over the white line they are. Fig.8.5 shows that aqua regia (AR) was the more significant effect in the dissolution of Nickel. Time is the second most significant effect. The interaction between aqua regia and time (AB) was almost as significant as time on its own and was more significant than the interaction between the different concentrations of aqua regia (AA). The difference in time (BB) was the least significant effect in the dissolution of nickel in aqua regia.

Fig.8.5 - Standardized Pareto Chart for Concentration of Nickel

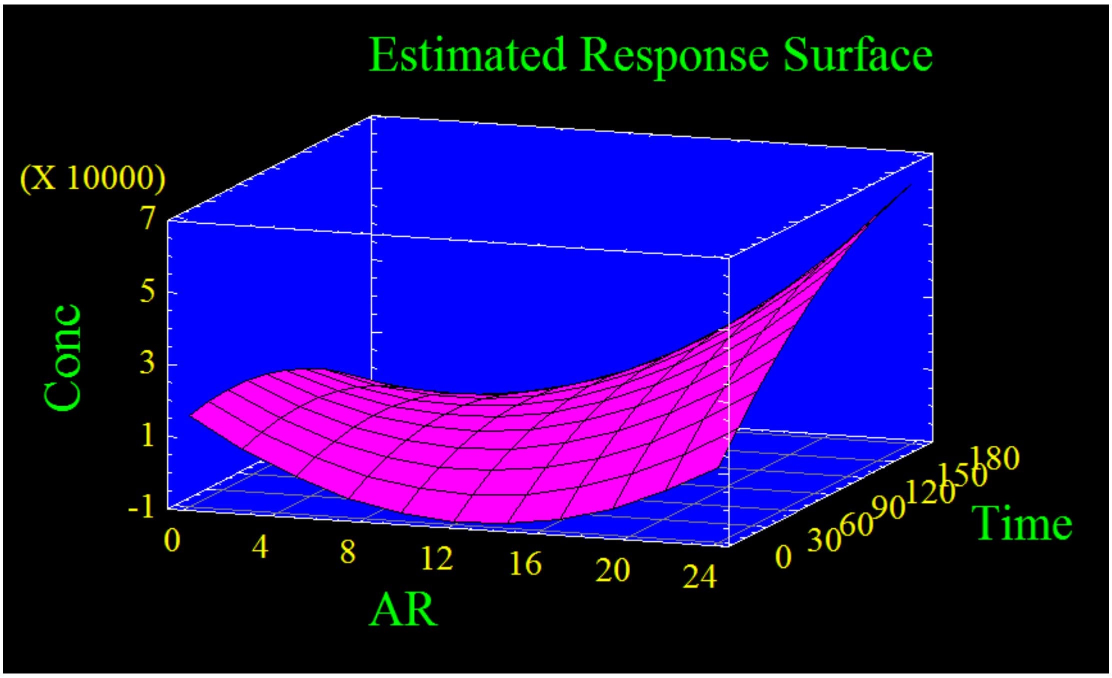



Legend: Conc = Concentration (mg/L); A:AR = Aqua regia (%); B:Time (hrs); AB = Aqua regia:Time; AA = Aqua reiga:aqua regia BB = Time:time

The estimated response surface (Fig.8.6) shows an estimate for the dissolution rate of nickel over a period of 180 hours in different concentrations of aqua regia (AR), ranging from 0 - 24%.

Fig.8.6 shows that at 24% aqua regia there is a dramatic increase in the amount of nickel being dissolved and the concentration of nickel goes from around 10000mg/L up to 70000mg/L by the end of the 180 hours. It also shows that if 12-16% aqua regia was used, it would produce the least concentrated amount of nickel, with a rather slow dissolution rate. Interestingly if 4-1% aqua regia was used, it would dissolve more nickel in the first few hours than the 24% aqua regia, with the dissolution of nickel being 15000mg/L and 10000mg/L respectively. The dissolution rate decreases between 150-180 hours into the experiment using 1-4% aqua regia.

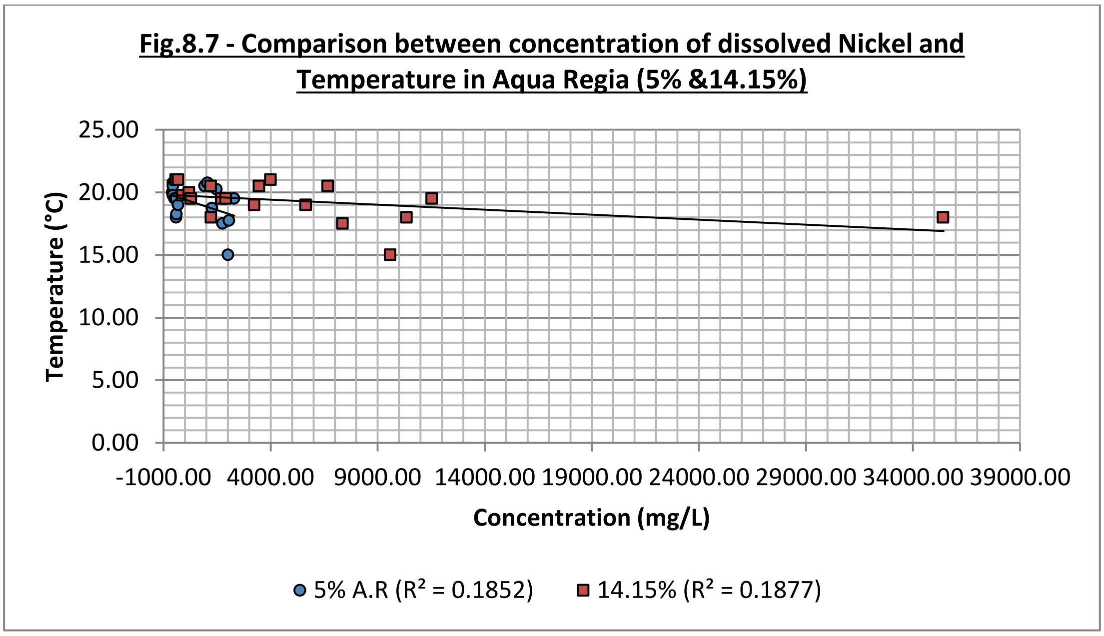
Fig.8.6 - Estimated Response Surface of Nickel

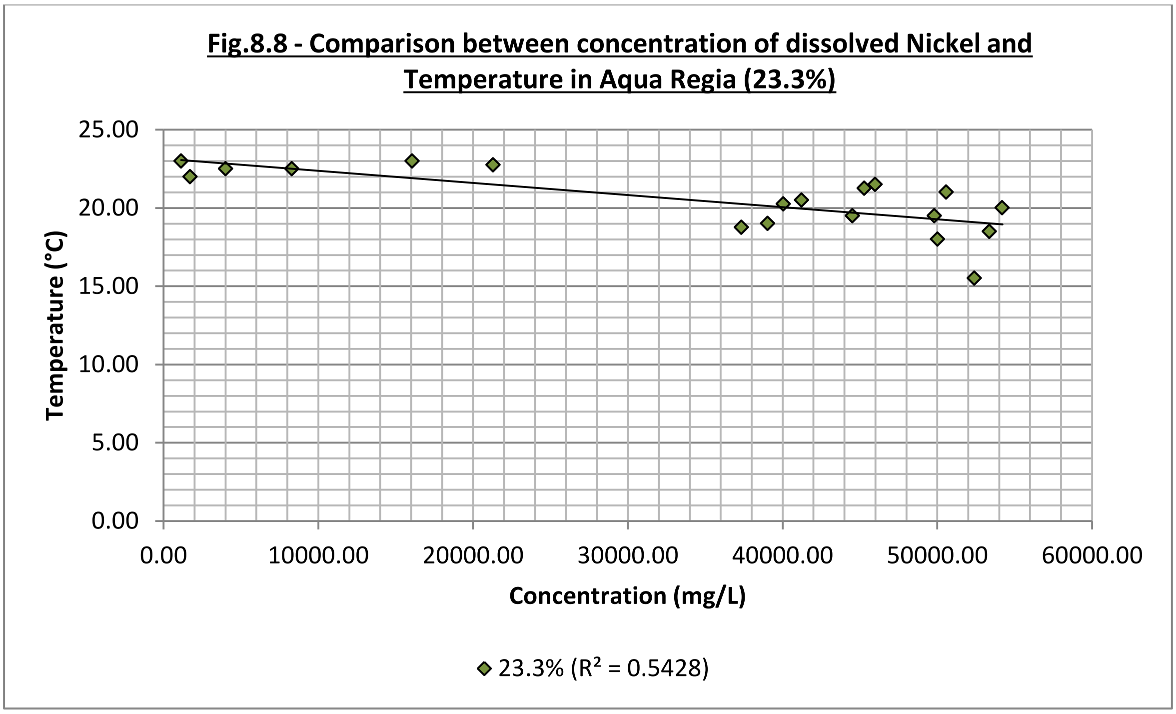



Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

### 3.1.1.4. Temperature

The temperature of the aqua regia solutions were recorded throughout the experiment at regular intervals. Fig.8.7 and Fig.8.8 show the comparison between the temperatures recorded in solution against the amount of nickel being dissolved to see if there was any correlation between the two variables. To look at the raw temperature data go to appendix 3c.




As shown by Fig.8.7 and Fig.8.8 there is no correlation between the two variables. All three concentrations of aqua regia have low $R^2$ values, with 5%, 14.15% and 23.3% producing $R^2$ values of 0.1852, 0.1877 and 0.5428 respectively. This means there is an extremely weak negative linear regression. It is also evident that the two variables do not relate to each other as the 5% and 14.15% aqua regia solutions dissolved around 0-10000mg/L of nickel whereas the 23.3% aqua regia dissolved 0-55000mg/L and yet all three solutions had temperatures in the range of 17-23°C.

### 3.1.2. Metal - Chromium

#### 3.1.2.1. Observations

Table 8a - 5% Aqua Regia Observations for Chromium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | no change | no change (fig.9a) |

Table 8b - 14.15% Aqua Regia Observations for Chromium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | light yellow | no change |
| 2 | no change | small quantity of debris at bottom of beaker |
| 3 | no change | debris dissolved |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | no change | no change (fig.9b) |

Table 8c - 23.3% Aqua Regia Observations for Chromium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | yellow, changed to dark green | very reactive, vigorous bubbles coming off metal |
| 2 | dark green | no more bubbles, debris in solution |
| 3 | no change | debris dissolved |
| 4 | no change | decreased in size |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | no change | decreased in size (fig.9c) |

Fig.9a - Chromium from 5% aqua regia

Fig.9b - Chromium from 14.15% aqua regia

Fig.9c - Chromium from 23.3% aqua regia

#### 3.1.2.2. Analytical Analysis

Two calibration graphs were produced by using standards of chromium where the concentration was known. The first calibration graph (Fig.10.1a) was created with low concentrations of known standards and was used for the 5% and 14.15% aqua regia chromium samples. The second calibration graph (Fig.10.1b) was obtained using higher concentration of standards and was used to calculate the concentrations of the 23.3% aqua regia chromium samples.

Table 9a shows the low concentrations used and the peak areas that were obtained by the AAS. Fig.10.1a shows the created calibration graph. To look at the raw calibration data go to appendix 4a.

Table 9a - Peak Areas against known concentrations (low)

| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 0.5 | 0.024 |
| 1 | 0.045 |
| 2 | 0.09 |
| 4 | 0.157 |

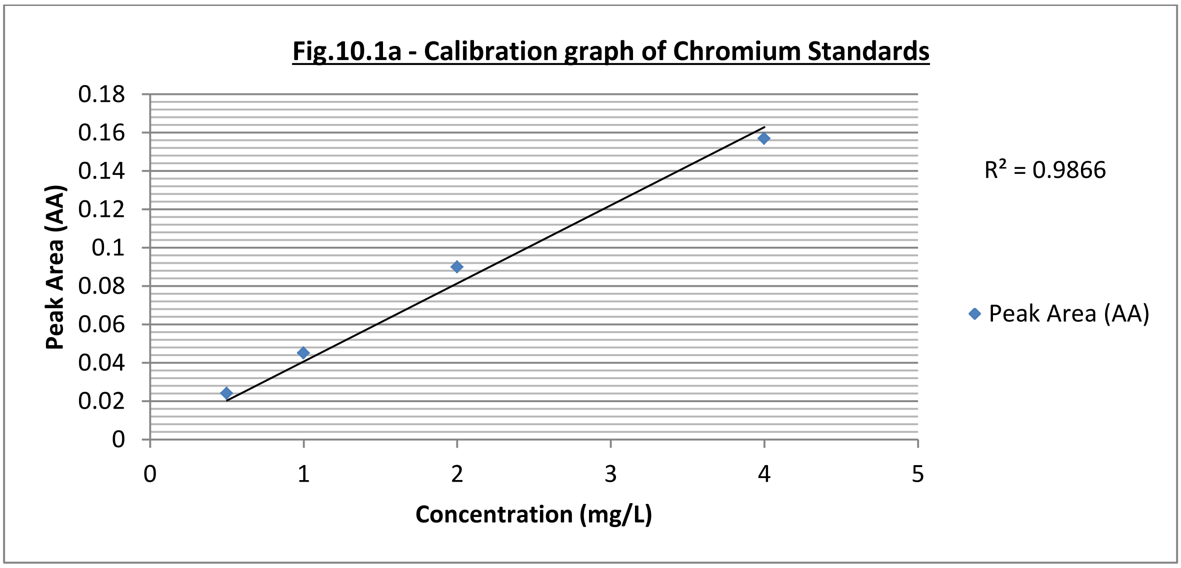
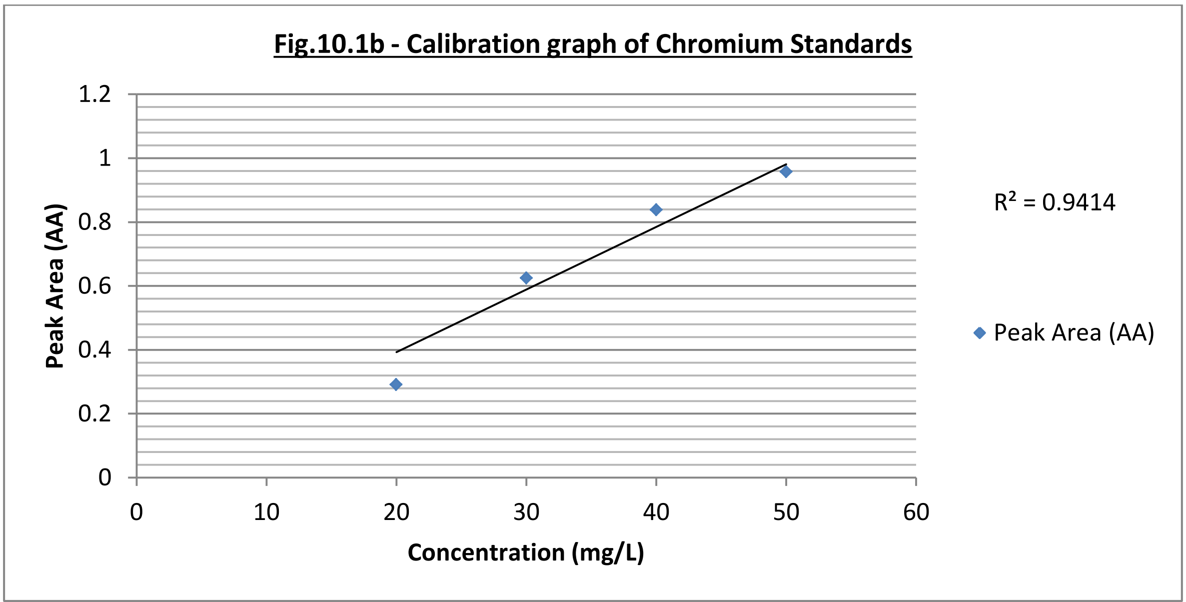


Table 9b shows the peak areas calculated by the AAS against the known concentrations of chromium standards. Fig.10.1b is the created calibration graph for the higher concentrated standards.

Table 9b – Peak Areas against known concentrations (high)

| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 20 | 0.291 |
| 30 | 0.625 |
| 40 | 0.838 |
| 50 | 0.957 |




Both calibrations graphs indicate that there is good positive linear regression as the $R^2$ value for Fig.10.1a is 0.9866 and the $R^2$ value for Fig.10.1b, despite being slightly lower, is 0.9414, which is still relatively close to the value of 1.

The AAS calculated all the concentrations for the samples of chromium and were calculated in mg/L. All the samples were diluted by a dilution factor of 1000 so to get the original concentration of the samples were multiplied by 1000. To see the raw AAS data of the chromium samples go to appendix 4b.

Fig.10.2 (which used Fig.10.1b calibration graph) shows that the 23.3% aqua regia solution had a very short time where the dissolution rate of chromium was high. After 1 hour, 2697.50mg/L of chromium was dissolved. This increased dramatically to 16953.33mg/L by hour 3. After 3 hours into the experiment, the dissolution rate seemed to slow dramatically and so the concentration of chromium in solution seemed to plateau. From hour 3 to 168 hours, only another 4275mg/L of chromium was dissolved.

Fig.10.2 - Progression of the dissolution of Chromium over a period of 168hrs in Aqua Regia

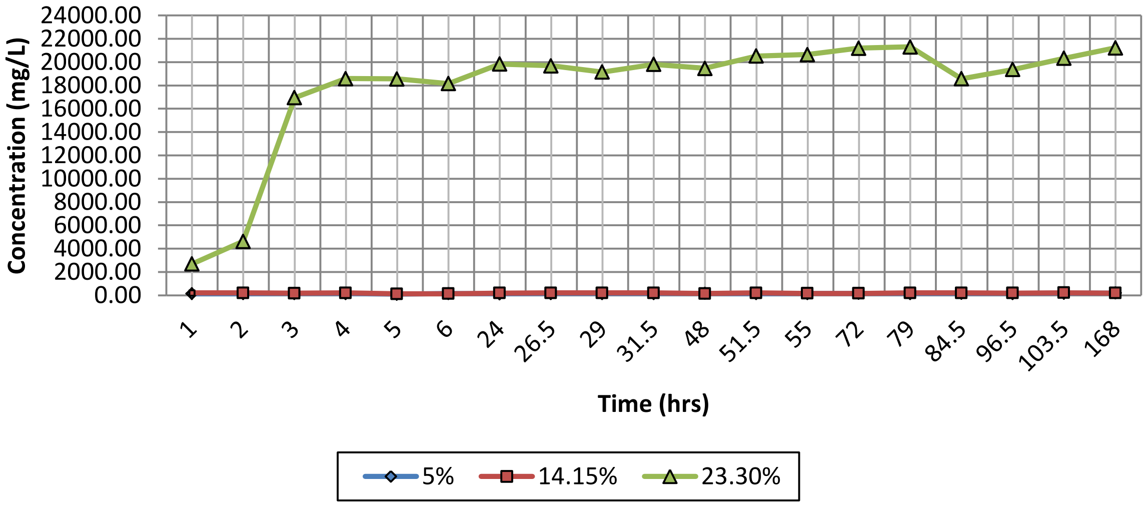



Fig.10.3 - Progression of Chromium dissolution in 5% and 14.15% Aqua Regia over a 168hr period

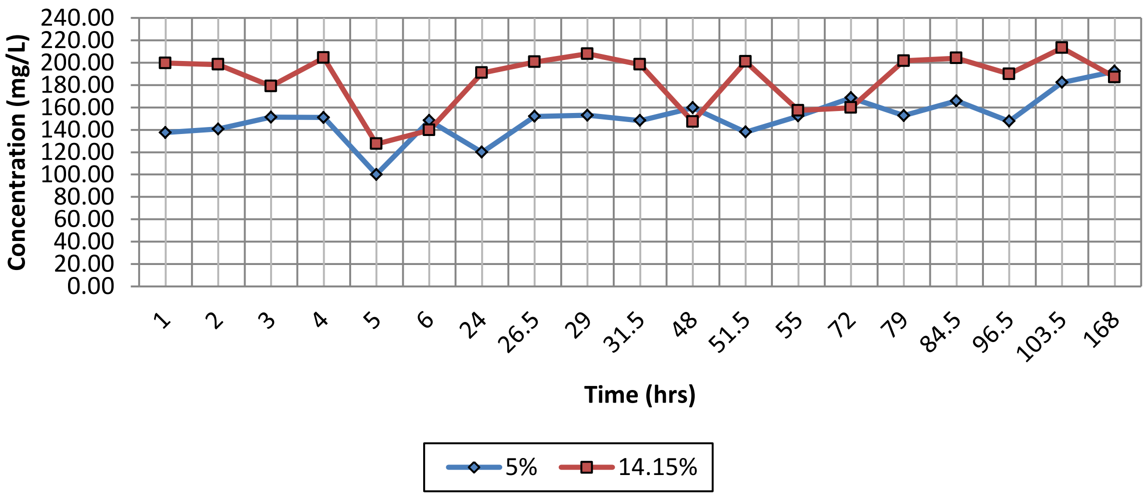



Fig.10.3 shows that even though both the 5% and 14.15% aqua regia solutions did not dissolve much chromium, the 14.15% aqua regia was slightly more effective than the 5% aqua regia. The 5% aqua regia dissolved 137.50mg/L of chromium after the first hour whereas the 14.15% aqua regia dissolved 199.67mg/L. The 14.15% aqua regia chromium samples seem to fluctuate much more than the 5% aqua regia chromium samples. For example, at hour 4 204.33mg/L had been dissolved by the 14.15% aqua regia. This then

dropped down to 127.33mg/L at hour 5 which you would not expect to see. Furthermore at 168 hours, the amount of chromium dissolved was 187.00mg/L which is 12.67mg/L less than what was dissolved by hour 1.

#### 3.1.2.3. Statistical Analysis

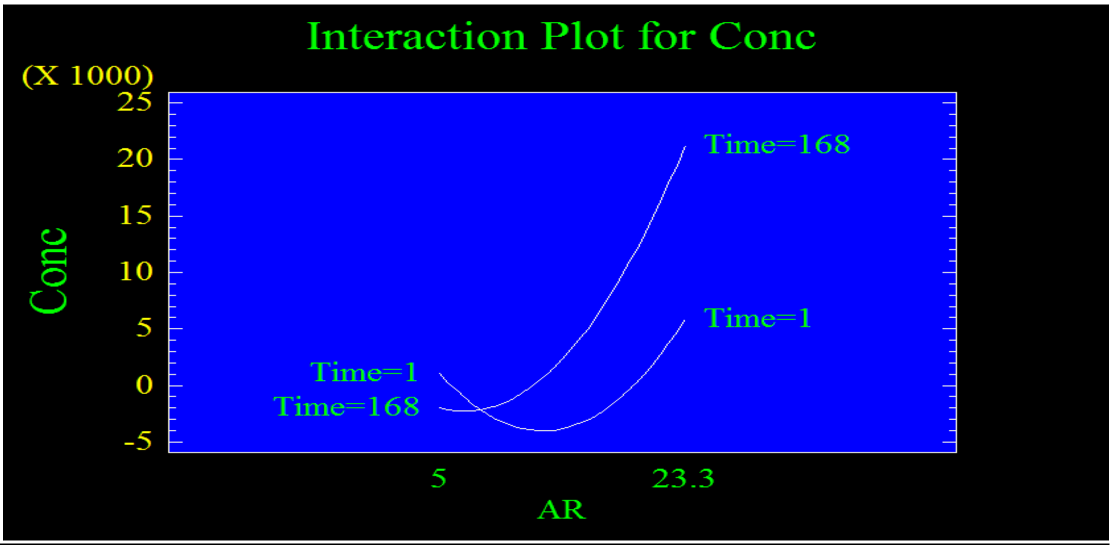
Table 10 shows the average concentrations of the samples that were run in the AAS in order to be used in the statgraphic software.

Table 10 - Concentrations of samples used in statgraphic software

| | 5% Aqua Regia | 14.15% Aqua Regia | 23.3% Aqua Regia |
|---|---|---|---|
| Time (hrs) | Concentration (mg/L) | | |
| 1 | 132.33 | 202.67 | 2663.33 |
| 1 (replica) | 142.67 | 196.67 | 2731.67 |
| 84.5 | 166.33 | 210.67 | 18830.00 |
| 84.5 (replica) | 165.33 | 184.00 | 18313.33 |
| 84.5 (replica) | - | 207.00 | - |
| 84.5 (replica) | - | 215.00 | - |
| 168 | 194.00 | 224.67 | 21033.33 |
| 168 (replica) | 190.67 | 149.33 | 21423.33 |

Different statistical graphs were created by adding the values from table 8 into the statgraphic software.

Fig.10.4 - Interaction Plot for the Concentration of Chromium

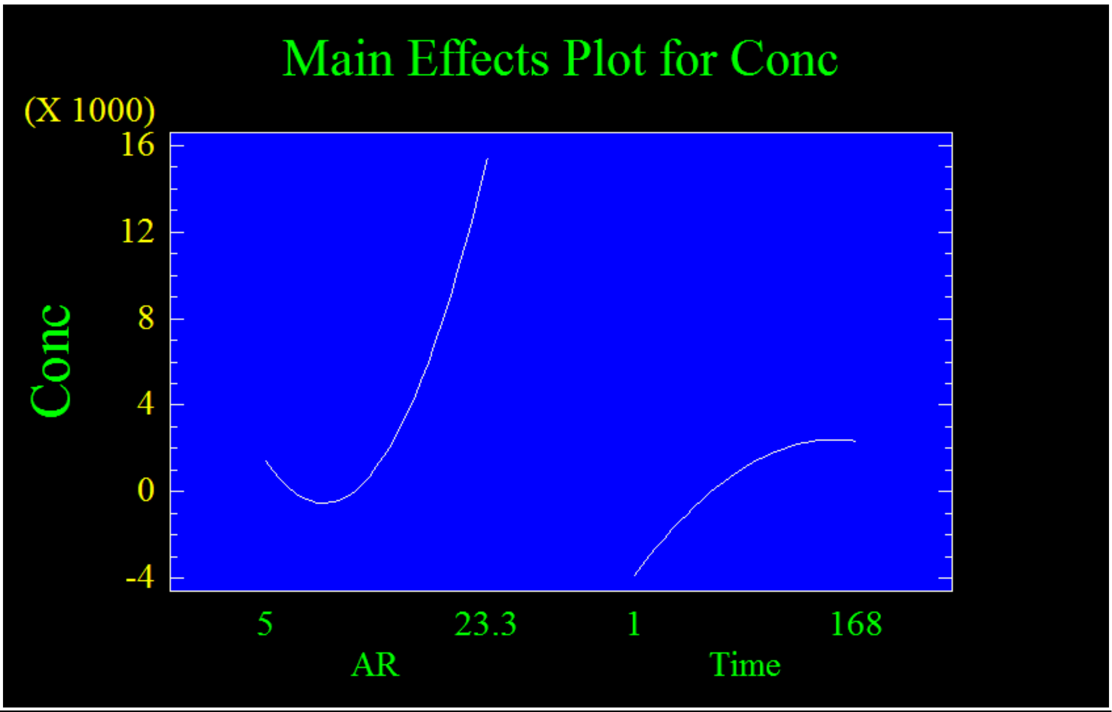



Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The interaction plot for the concentration of chromium (Fig.10.4) indicates that within the first hour of dissolution there is not much difference between using 5% aqua regia (AR) and 23.3% aqua regia. The 5% aqua regia dissolved around 2000mg/L of chromium and the 23.3% only dissolved around 5000mg/L. As the time progressed and the experiment reached 168 hours, the difference between using 5% aqua regia and 23.3% aqua regia increases dramatically. At 168 hours, the 5% aqua regia actually decreased in the dissolution rate, whereas on contrast, the 23.3% aqua regia had dissolved around 21000mg/L of chromium.

The main effects plot for the concentration of chromium (Fig.10.5) shows that using 5% aqua regia will give more dissolution that some of the higher concentration of aqua regia, however, as the aqua regia strength get closer to 23.3% the amount of dissolution starts to increase very quickly and is almost sixteen times more effective than using the 5% aqua regia. The graph suggests that time has a slow effect on the amount of chromium being dissolved as there is a steady increase as time progresses; however it then starts to plateau as the time reaches near to 168 hours.

Fig.10.5 - Main Effects Plot for Concentration of Chromium

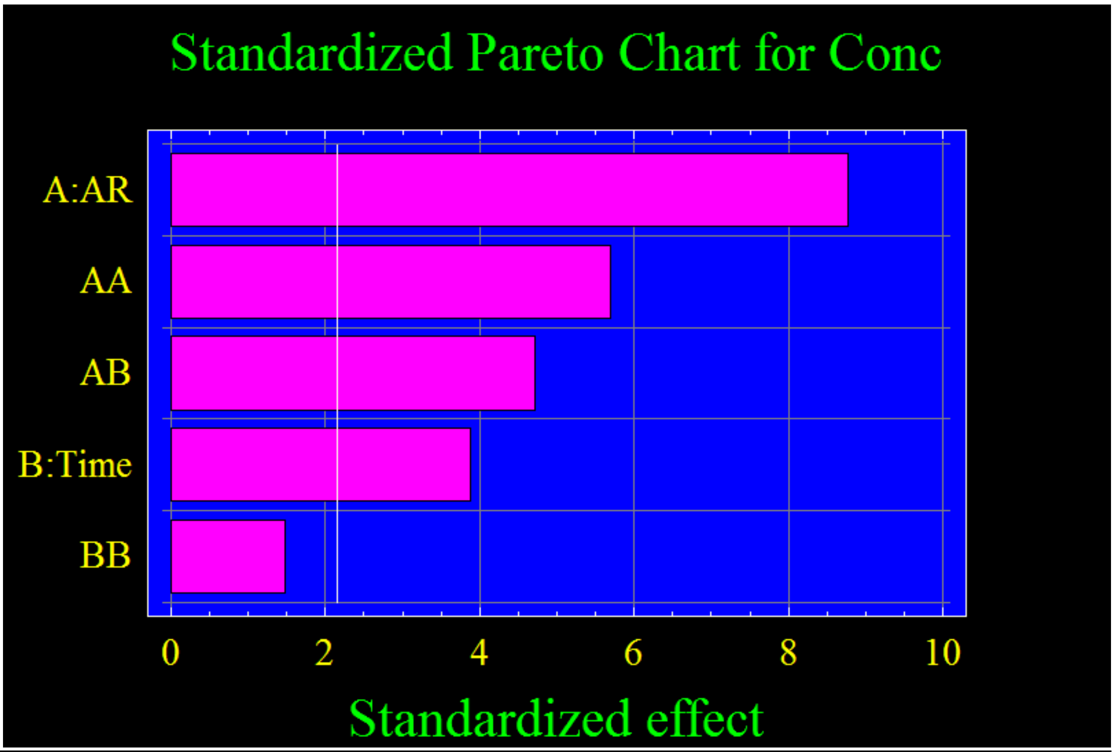



Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The standardized pareto chart for the Concentration of chromium (Fig.10.6) shows which variables are significant in the dissolution of chromium in aqua regia.

Aqua regia (A) seems to be the most significant variable that determines how well chromium will dissolve. Unlike with nickel, where time (B) was the next most significant effect, with chromium the different concentrations of aqua regia (AA) were the next most significant with time (B) being the least significant factor in the dissolution of chromium. The duration of time (BB) that the chromium was in solution is an insignificant effect as it is below the white line.

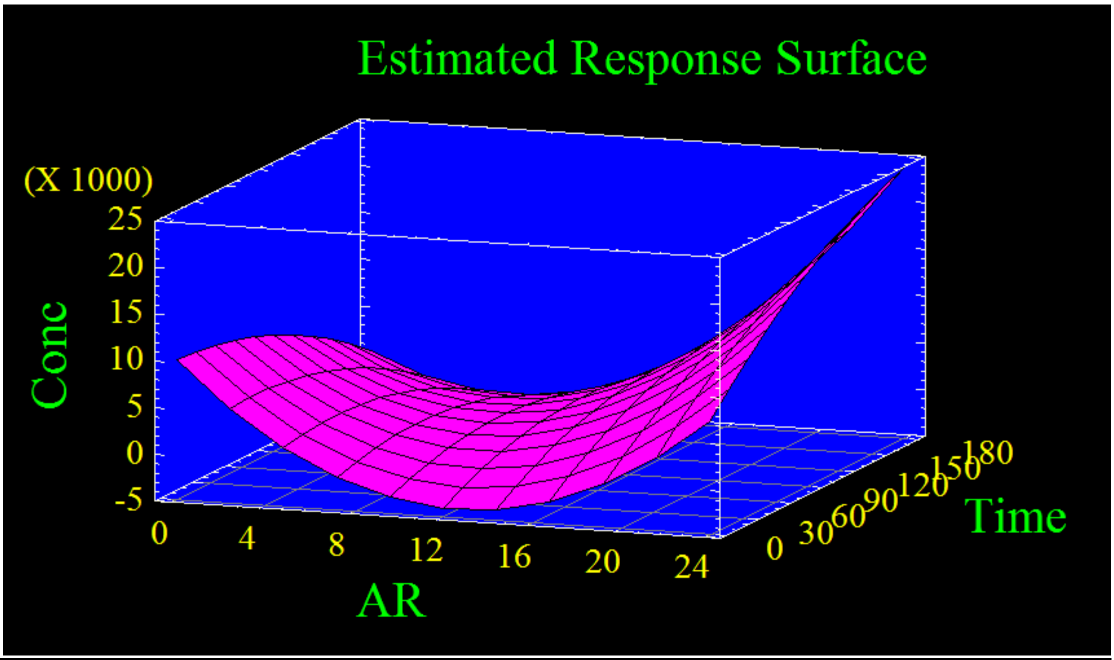
Fig.10.6 - Standardized Pareto Chart for Concentration of Chromium




Legend: Conc = Concentration (mg/L); A:AR = Aqua regia (%); B:Time (hrs); AB = Aqua regia:Time; AA = Aqua reiga:aqua regia BB = Time:time

The estimated response surface (Fig.10.7) estimated that if a high concentration of aqua regia (AR) is used (24%) than that would give the best result in the dissolution of chromium by the end of the 180 hours with a concentration of chromium in solution at 25000mg/L. Using a 1% aqua regia solution would dissolve more chromium in the first hour. 1% aqua regia would dissolve 10000mg/L and 24% would dissolve 7500mg/L, however the dissolution rate of the chromium would decrease over time using 1% aqua regia where as with the 24% aqua regia solution the dissolution rate would increase, therefore being more beneficial.

Fig.10.7 - Estimated Response Surface of Chromium

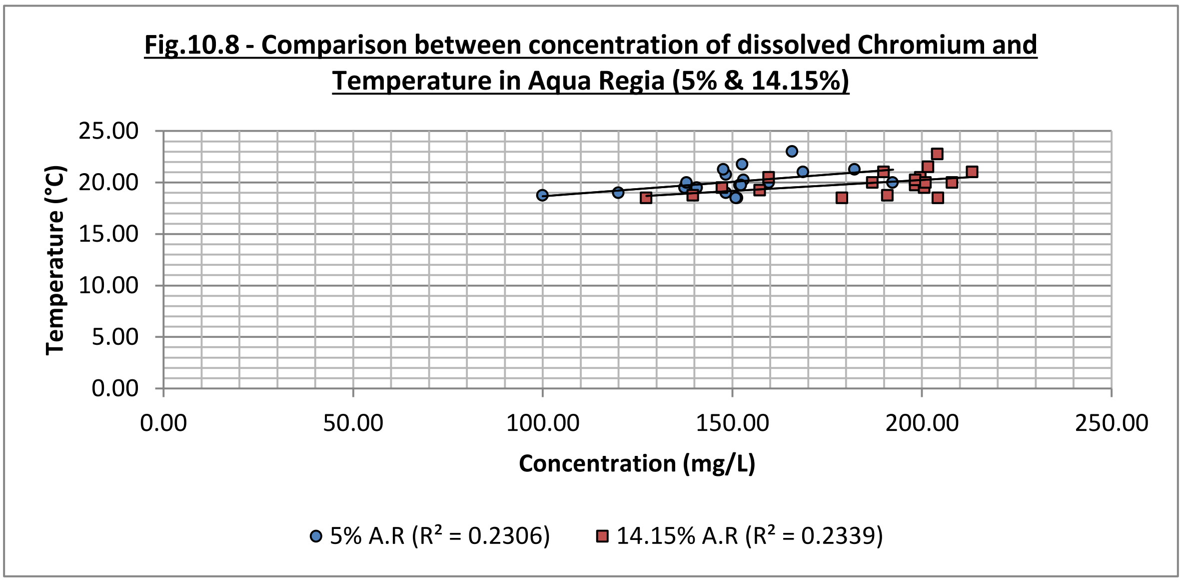



Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

### 3.1.2.4. Temperature

The temperatures recorded throughout the experiment were compared with the concentrations of chromium in solution to see if there was a correlation which could possibly indicate that temperature has an effect on the rate of dissolution.

Fig.10.8 and Fig.10.9 show the comparison between the temperature and the concentration of chromium. To look at the raw temperature data, go to appendix 4c.



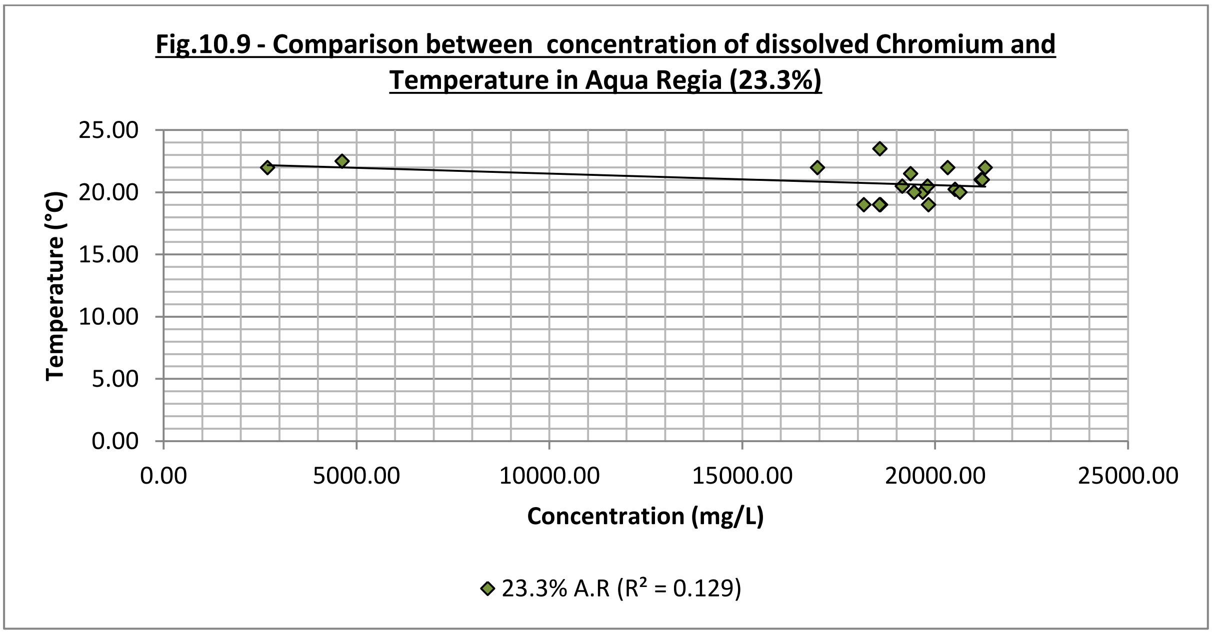




Fig.10.8 shows that both the 5% and 14.15% aqua regia solutions have a very weak, positive linear regression as their $R^2$ values are 0.2306 and 0.2339 respectively. Despite the 14.15% aqua regia solution having a slightly higher concentration of chromium the temperatures of both the 5% and 14.15% are very similar.

Fig.10.9 indicates that there is an extremely weak, negative linear regression with an $R^2$ value of 0.129. There is not a significant difference in the temperature of the aqua regia when 3000 - 5000mg/L of chromium was dissolved and when 17000 - 21000mg/L of chromium was dissolved.

### 3.1.3. Metal - Aluminium

Aluminium was only tested in the 5% aqua regia solution (fig.11a).

#### 3.1.3.1. Observations

Table 11 - 5% Aqua Regia Observations for Aluminium

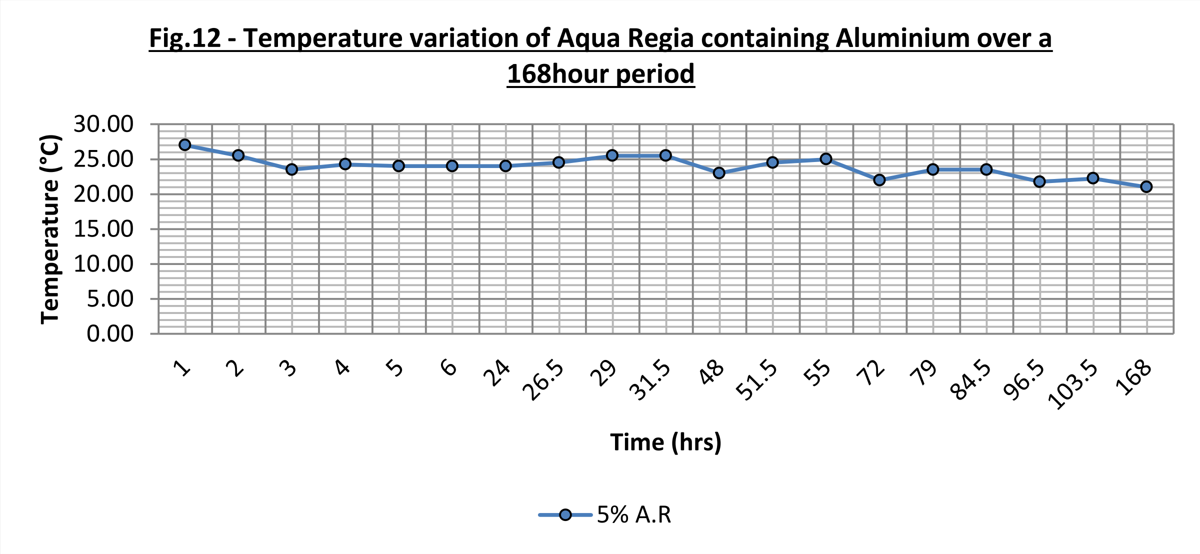
| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | lost its shiny appearance |
| 5 | no change | no change |
| 6 | - | |
| 7 | - | |
| 8 | no change | surface rough and porous in appearance (fig.11b) |

Fig.11a - Aluminium before being in aqua regia

Fig.11b - Aluminium after being in 5% aqua regia

#### 3.1.3.2. Temperature

Fig.12 shows the temperature of the aqua regia solution for the duration of the experiment. It is evident that the temperature did not fluctuate very much and stayed on average at 24.17°C. This indicates that despite the observation that some of the aluminium was dissolved, this was not due to a fluctuation in temperature.




### 3.1.4. Metal - Cobalt

3.1.4.1. Observations

Table 12a - 5% Aqua Regia Observations for Cobalt

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | light pink | no change |
| 2 | intense pink | no change |
| 3 | no change | no change |
| 4 | no change | holes formed, porous in appearance |
| 5 | - | - |
| 6 | - | - |
| 7 | dark pink (fig.13a) | more holes formed |
| 8 | no change | dull in colour (fig.13b) |

Table 12b - 14.15% Aqua Regia Observations for Cobalt

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | light blue | no change |
| 2 | intense blue | no change |
| 3 | no change | decreased in size |
| 4 | no change | decreased in size |
| 5 | - | - |
| 6 | - | - |
| 7 | dark blue (fig.13c) | shiny, smooth surface (fig.13d) |
| 8 | no change | no change |

Table 12c - 23.3% Aqua Regia Observations for Cobalt

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | orange, changed to dark blue very quickly | appearance obstructed by solution colour |
| 2 | very dark blue (almost black looking) (fig.13e) | appearance obstructed by solution colour |
| 3 | no change | appearance obstructed by solution colour |
| 4 | no change | appearance obstructed by solution colour |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | appearance obstructed by solution colour |
| 8 | no change | once removed, appearance was shiny, reduced in size and smooth surface (fig.13f) |

Fig.13a - 5% aqua regia colour after 7 days


Fig.13c - 14.15% aqua regia colour after 7 days


Fig.13e - 23.3% aqua regia colour after 2 days

Fig.13b - Cobalt looking porous from 5% aqua regia

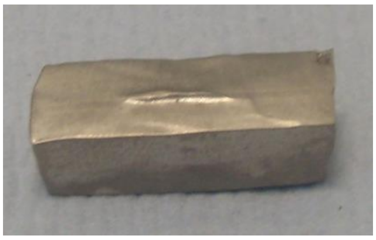


Fig.13d - Cobalt looking smooth from 14.15% aqua regia

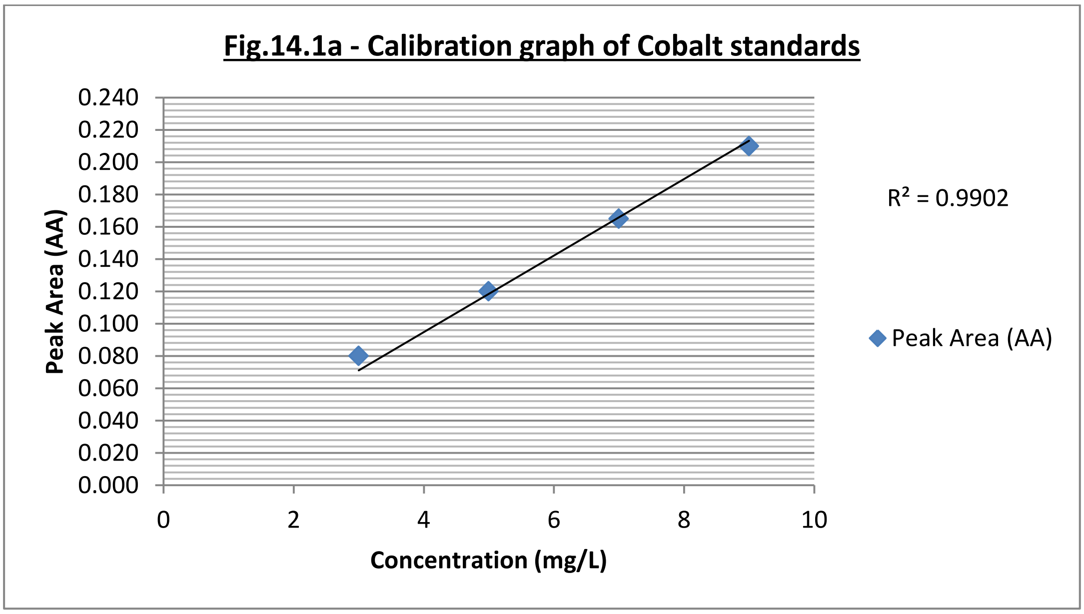
Fig.13f - Cobalt from 23.3% aqua regia

### 3.1.4.2. Analytical Analysis

In order to calculate the concentrations of the cobalt samples, two calibration graphs were needed. Fig.14.1a was the first calibration graph which used low concentrations and was used for the 5% and 14.15% aqua regia cobalt samples. Table 13a shows the concentrations of known standards used with the average peak areas that were obtained by the AAS. Fig.14.1a shows the calibration graph. To see the calibration raw data go to appendix 5a.

Table 13a - Peak Areas against known concentrations (low)

| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 3 | 0.080 |
| 5 | 0.120 |
| 7 | 0.165 |
| 9 | 0.210 |



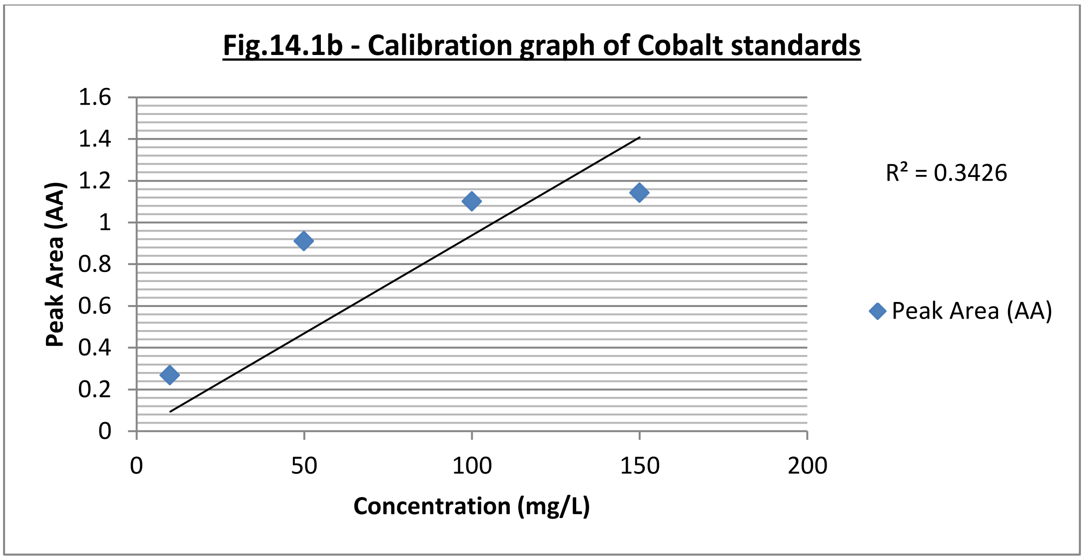

The calibration graph shows that there is good positive linear regression as the $R^2$ value is 0.9902, which is very close to the desired figure of 1.

The second calibration graph that was created used higher concentrations of known standards of cobalt. This calibration graph was used to calculate the concentrations of the 23.3% aqua regia cobalt samples. Table 13b shows the known standards and the peak areas that were generated by the AAS.

Table 13b - Peak Areas against known concentrations (high)

| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 10 | 0.268 |
| 50 | 0.911 |
| 100 | 1.100 |
| 150 | 1.142 |

The calibration graph (Fig.14.1b) is what was obtained with the results from table 13b.




Unfortunately the calibration graph (Fig.14.1b) has a weak positive linear regression as the $R^2$ value is 0.3426. This is low which means there would be some potential errors in the concentrations obtained by the aqua regia cobalt samples. The weak linear regression was probably due to the high concentrations of known standards being used and so was outside the linearity range of the AAS.

The AAS generated the concentrations from all the samples of dissolved cobalt and all results were calculated in mg/L.

The samples had been diluted by a dilution factor of 1000; therefore, all the results obtained by the AAS were multiplied by 1000 to get the original concentration. To see the raw data of the cobalt samples go to appendix 5b.

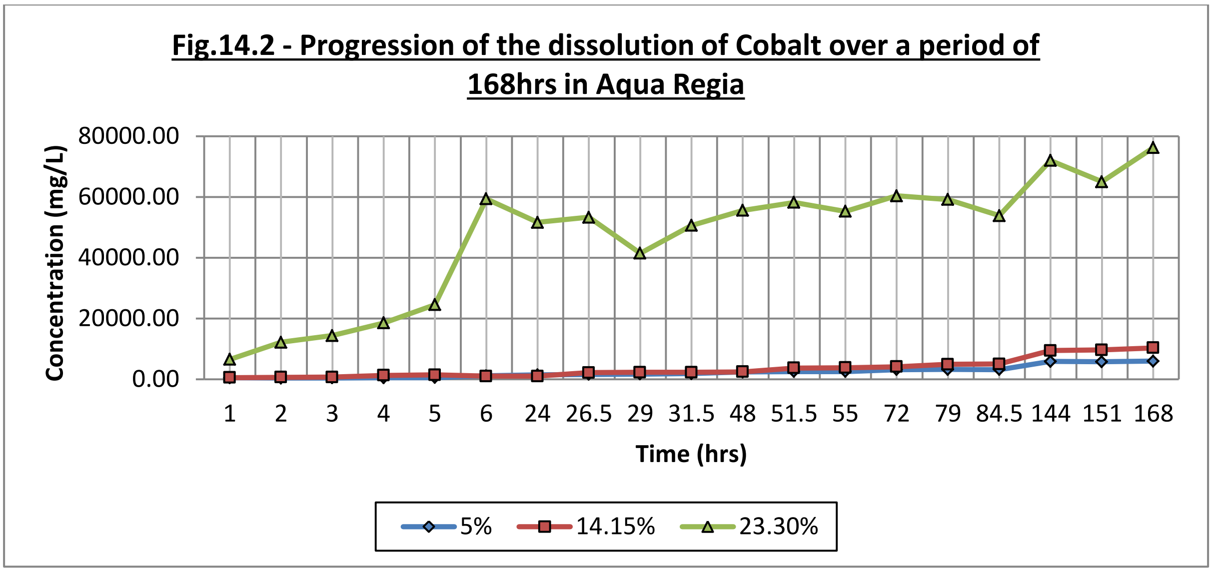



Fig.14.2 shows that the 23.3% aqua regia cobalt samples had a slow dissolution rate. Within the first hour of dissolution 6506mg/L of cobalt had been dissolved. This increased to 24543.33mg/L by hour 5. Between hours 5 and 6 there was a high increase in the amount of cobalt being dissolved and the amount that had been dissolved by hour 6 was 59356.67mg/L. The graph seems to plateau from hours 6 to 168 hours with there being a very gradual dissolution rate with only another 16841.67mg/L of cobalt being dissolved. Despite the weak calibration graph (Fig.14.1b) it is evident that the 23.3% aqua regia had dissolved more cobalt than the 5% and 14.15% aqua regia solutions.

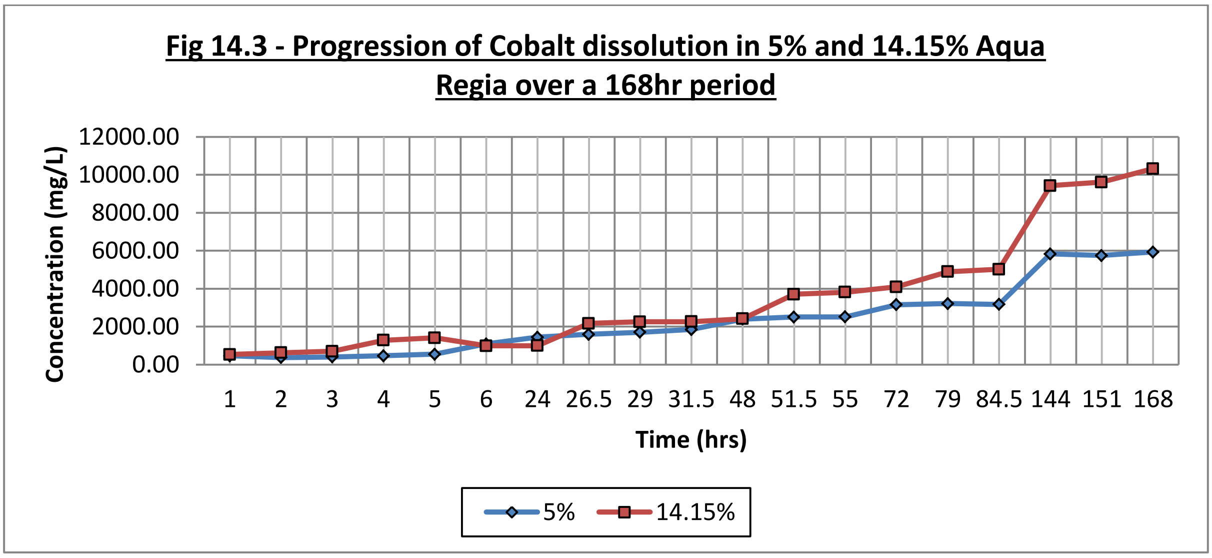



Fig.14.3 shows the 14.15% aqua regia solution dissolved more cobalt than the 5% solution. From hours 1 to 48 both the 5% and 14.15% aqua regia solutions had dissolved around the same amount of cobalt, but after this time the 14.15% started to dissolve more. By the end

of the experiment (168 hours) the 14.15% aqua regia solution had dissolved 57.4% more cobalt than the 5% aqua regia solution.

#### 3.1.4.3. Statistical Analysis

The averages for the samples that were run the AAS to be used in the statgraphic software are in Table 14.

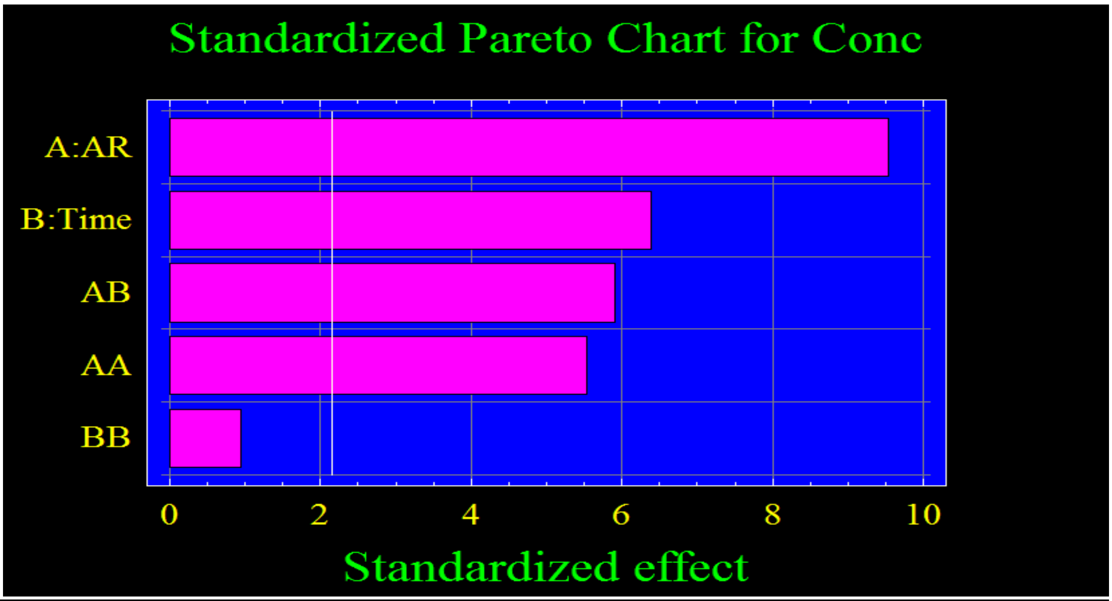
Table 14 - Concentrations of samples used in statgraphic software

| | 5% Aqua Regia | 14.15% Aqua Regia | 23.3% Aqua Regia |
|---|---|---|---|
| Time (hrs) | Concentration (mg/L) | | |
| 1 | 273.33 | 525.33 | 6431.00 |
| 1 (replica) | 646.67 | 540.33 | 6581.00 |
| 84.5 | 3145.67 | 4989.00 | 49070.00 |
| 84.5 (replica) | 3194.33 | 5030.33 | 58473.33 |
| 84.5 (replica) | - | 5028.67 | - |
| 84.5 (replica) | - | 5042.73 | - |
| 168 | 5961.00 | 10586.67 | 699966.67 |
| 168 (replica) | 5892.00 | 10047.67 | 82430.00 |

The values in table 14 were inserted into the statgraphic software and the following statistical graphs were generated.

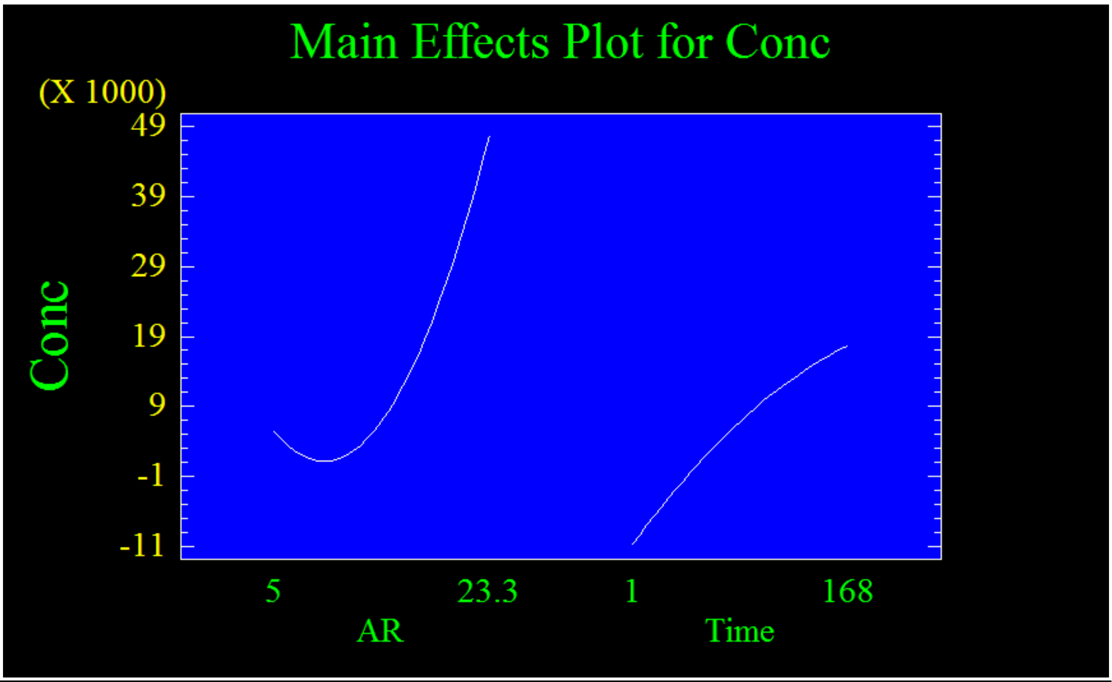
The standardized pareto chart for the concentration of cobalt (Fig14.4) shows that aqua regia (A) is the most significant factor in the success of dissolving cobalt. The interaction between the aqua regia (AA) is significant but is not as significant as time (B) or the interaction between aqua regia and time (AB). The interaction (duration) of time (BB) is an insignificant effect as it is below the white line.

Fig.14.4 - Standardized Pareto Chart for Concentration of Cobalt




Legend: Conc = Concentration (mg/L); A:AR = Aqua regia (%); B:Time (hrs); AB = Aqua regia:Time; AA = Aqua reiga:aqua regia BB = Time:time

Fig.14.5 - Main Effects Plot for Concentration of Cobalt



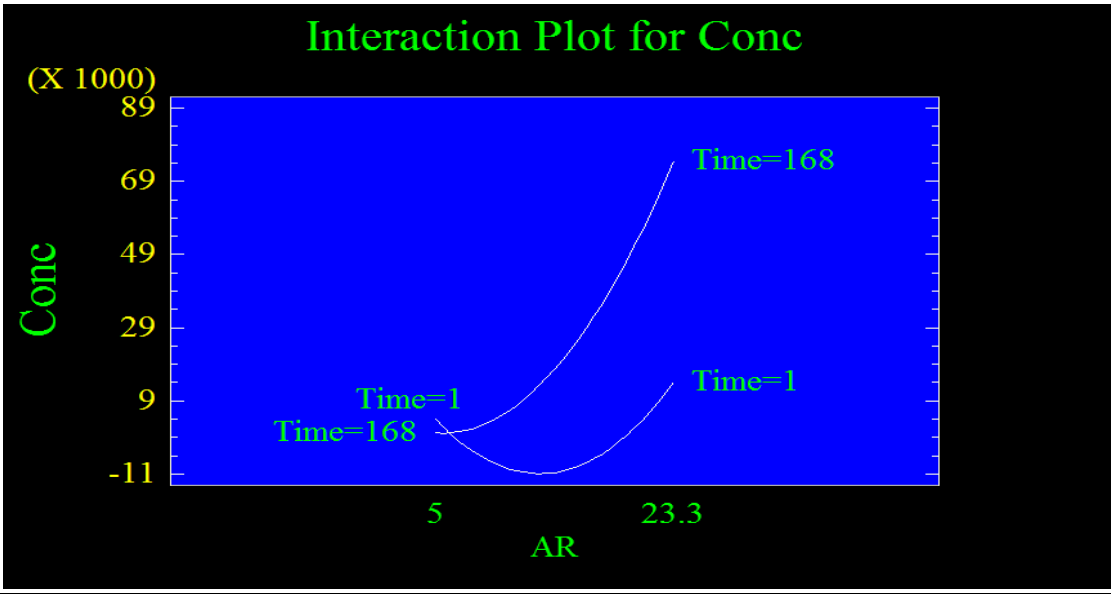

Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The main effects plot for the concentration of cobalt (Fig.14.5) shows that the 23.3% aqua regia solution will give the most concentration of cobalt. The effectiveness on the amount of cobalt being dissolved reduces dramatically as the strength of aqua regia decreases, however when the strength of aqua regia is near 5%, the amount of cobalt being dissolved actually increases slightly.

Time shows that as the duration increases the quantity of cobalt being dissolved is increased dramatically from hour 1 not dissolving anything (in negative figures) to 19000mg/L of cobalt being dissolved aft 168 hours. This contradicts the standardized pareto chart (Fig14.4) as it suggested that the interaction with time (BB) is an insignificant effect.

The interaction plot for the concentration of cobalt (Fig14.6), shows that when 23.3% aqua regia is used, the duration at which the cobalt is subjected to the acid has a significant difference into the amount of cobalt being dissolved. Within the first hour around 9000mg/L of cobalt could be dissolved, however 168 hours later, over 69000mg/L of cobalt could be dissolved. The difference between the amount of cobalt being dissolved from hour 1 to hour 168 decreases as the strength of aqua regia decreases and by 5% aqua regia time becomes insignificant as after 1 hour more cobalt would be dissolved than after 168 hours.

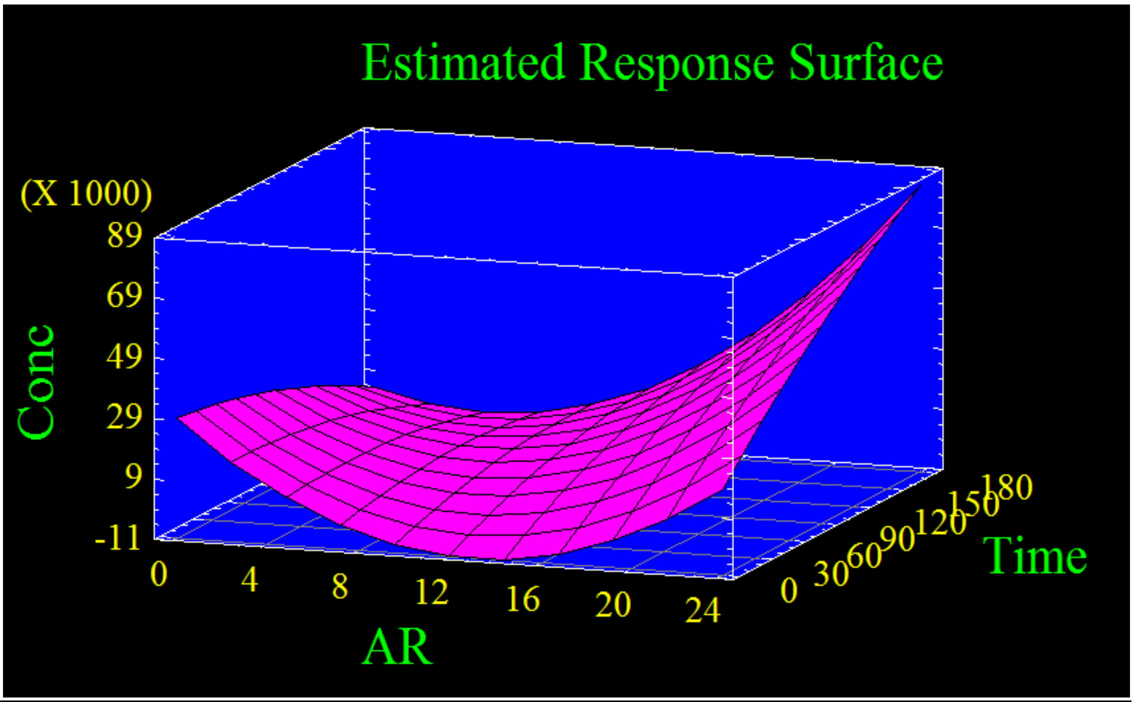
Fig.14.6 - Interaction Plot for Concentration of Cobalt




Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The estimated response surface (Fig.14.7) suggests that strength of aqua regia from 16 - 24% will give you a steady dissolution rate, with 24% aqua regia dissolving the most amount of cobalt. The low strength of aqua regia (1-8%) would still dissolve cobalt; however the dissolution plateaus after a few hours and so no more cobalt would be dissolved. A maximum of 29000mg/L of cobalt could be dissolved with 1% aqua regia, where as maximum of 89000mg/L of cobalt could be dissolved using 24% aqua regia.

Fig.14.7 - Estimated Response Surface of Cobalt




Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

### 3.1.4.4. Temperature

Looking to see if there is a relationship between the concentration of cobalt and the temperature of the aqua regia, it is evident that there is no real correlation.

Fig.14.8 shows that there is a weak negative linear regression, as the $R^2$ values for the 5% and 14.15% aqua regia solutions are 0.3743 and 0.4342 respectively. The 14.15% aqua regia does show a slight trend that at lower concentrations of cobalt (400 - 2000mg/L), the temperature was marginally higher (between 22 - 24°C), than when there was a high concentration of cobalt in solution (10000mg/L) when the temperature had dropped to 20°C.

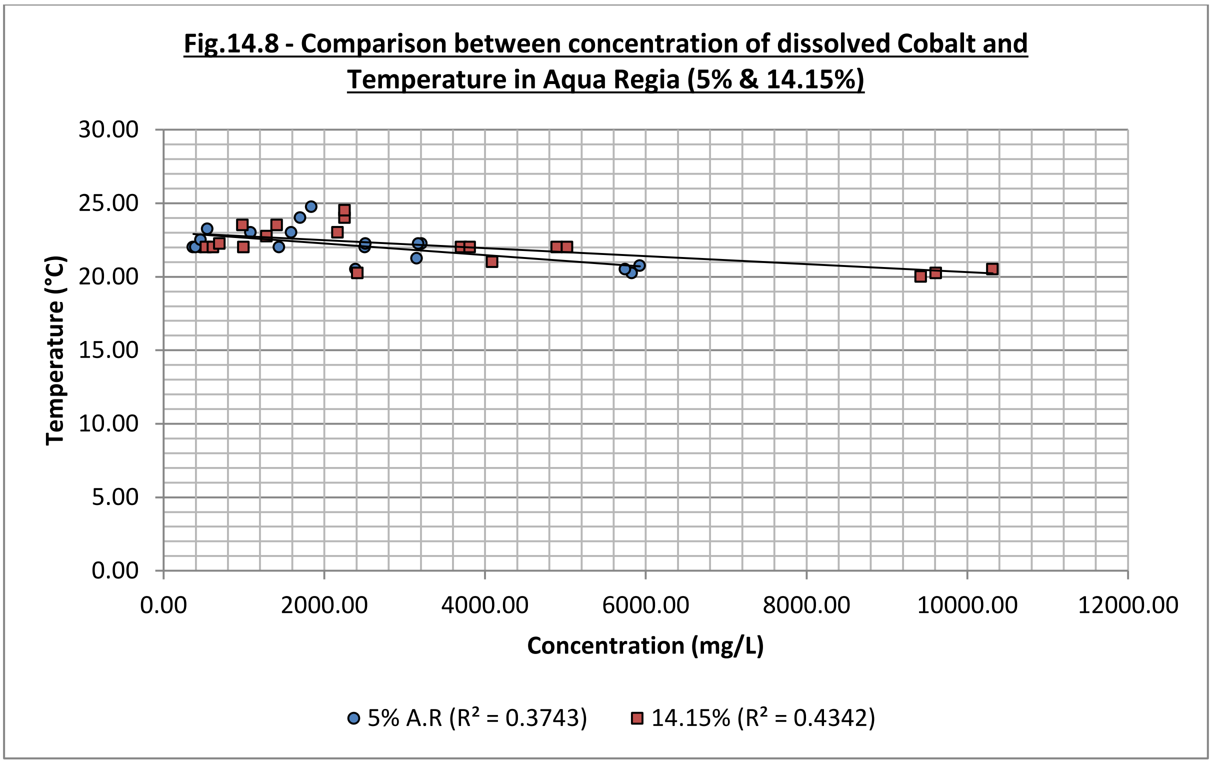
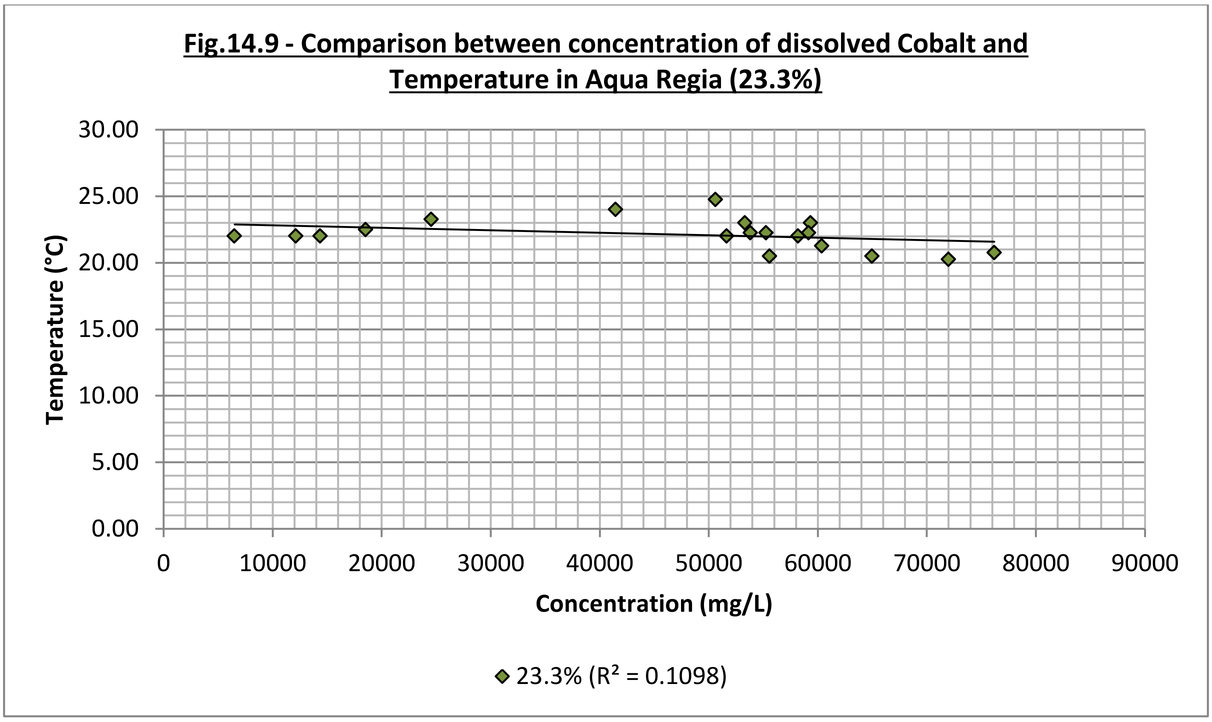



Fig.14.9 shows there is an extremely weak, negative linear regression, as the $R^2$ value is 0.1098. Despite the increase in concentration of cobalt, from 6000mg/L to 76000mg/L the temperatures stayed within the range of 20 - 24°C.

To look at the raw temperature data go to appendix 5c.



### 3.1.5. Metal - Hafnium

#### 3.1.5.1. Observations

Table 15a - 5% Aqua Regia Observations for Hafnium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | no change | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | no change | no change |

Table 15b - 14.15% Aqua Regia Observations for Hafnium

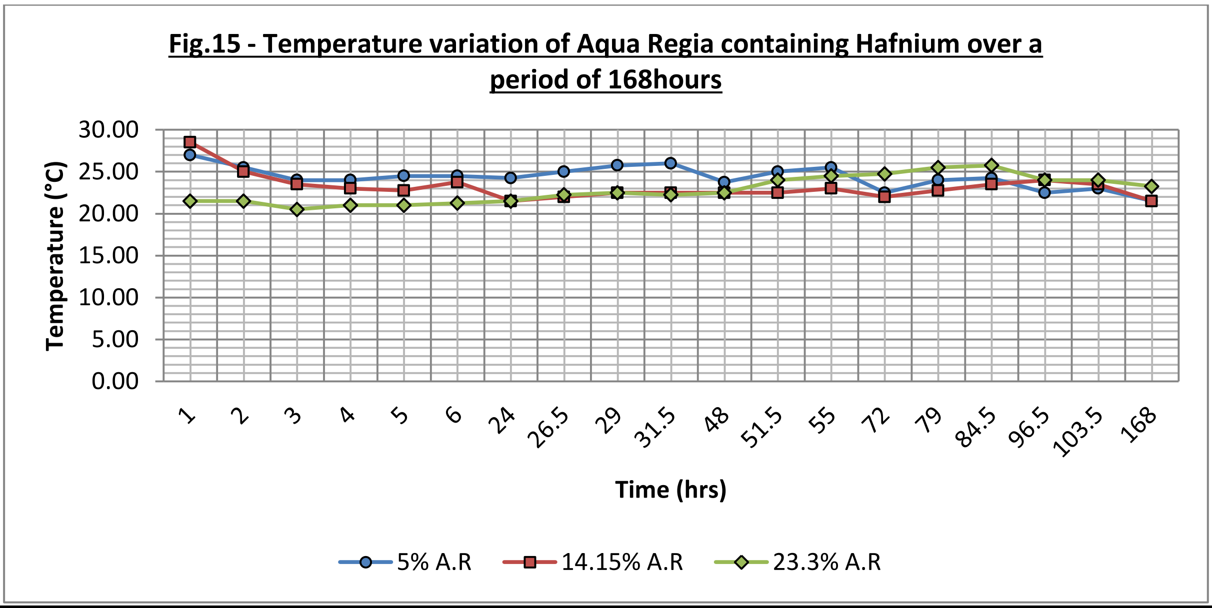
| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | light yellow | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | |
| 7 | - | |
| 8 | pale yellow | no change |

Table 15c - 23.3% Aqua Regia Observations for Hafnium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | orange | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | light yellow | no change |

#### 3.1.5.2. Temperature

The temperatures in Fig.15 show that the 5% aqua regia solutions temperature gradually decreased over the 168 hours period, from 27°C down to 21.5°C. The 14.15% aqua regia solution had the highest temperature within the first hour, at 28.5°C, however this slowly decreased as time progressed. The 23.3% aqua regia had little change in the temperature throughout the experiment apart from between hours 51.5 - 84.5 where the temperature had increased slightly.




### 3.1.6. Metal - Molybdenum

#### 3.1.6.1. Observations

Table 16a - 5% Aqua Regia Observations for Molybdenum

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | no change |
| 2 | no change | small quantity of debris at bottom of beaker |
| 3 | no change | more debris at bottom of beaker |
| 4 | no change | debris started to dissolve |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | debris dissolved |
| 8 | light orange | no noticeable change in size of metal (fig.16a) |

Table 16b - 14.15% Aqua Regia Observations for Molybdenum

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | gold | bubbles coming off metal |
| 2 | red/brown | no bubbles |
| 3 | no change | no change |
| 4 | no change | noticeably smaller in size |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | decreased in size |
| 8 | no change | decreased in size (fig.16b) |

Table 16c - 23.3% Aqua Regia Observations for Molybdenum

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | orange, changed to red | very reactive, lots of bubbles coming off metal |
| 2 | no change | decreased in size |
| 3 | no change | decreased in size |
| 4 | no change | decreased in size |
| 5 | - | - |
| 6 | - | - |
| 7 | light red | metal fully dissolved |
| 8 | no change | no change |

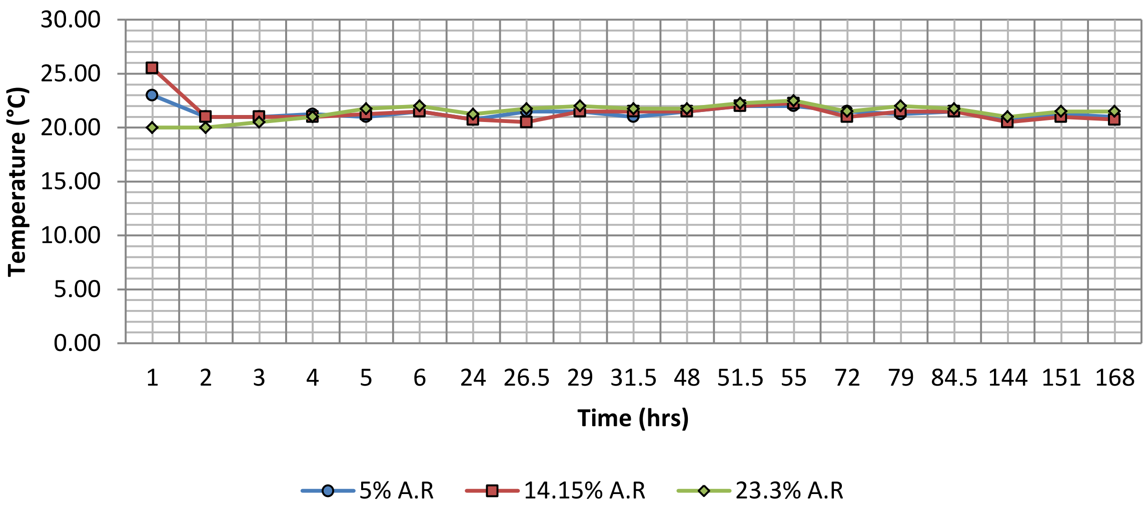
Fig.16a - Molybdenum from 5% aqua regia

Fig.16b - Molybdenum from 14.15% aqua regia

3.1.6.2. Temperature

Looking at the temperature variation in Fig.17 it shows that all the three strengths of aqua regia had extremely similar temperatures throughout the experiment with the only big difference being the temperature after one hour into the experiment. The 14.15% aqua regia had the highest temperature at 25.5°C, followed by the 5% aqua regia at 23°C, with the 23.3% aqua regia having a temperature of 20°C after the first hour of the experiment. The fact that the temperatures are very similar during the duration of the experiment, despite the fact that the 23.3% and 14.15% aqua regia dissolved molybdenum, it would indicate that temperature, in the range of 20 - 26°C does not have an effect on the rate of dissolution.

**Fig.17 - Temperature variation of Aqua Regia containing Molybdenum over a period of 168hours**




### 3.1.7. Metal - Rhenium

The rhenium was only tested in the 5% and 14.15% aqua regia solution.

3.1.7.1. Observations

Table 17a - 5% Aqua Regia Observations for Rhenium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | air bubbles on surface of metal |
| 2 | no change | air bubbles disappeared |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | no change | no change (fig.18) |

Table 17b - 14.15% Aqua Regia Observations for Rhenium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | light yellow | bubbles coming off metal |
| 2 | dark yellow | debris on bottom of beaker |
| 3 | no change | metal broken down into powder form |
| 4 | no change | fully dissolved |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | light yellow | no change |

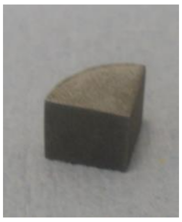


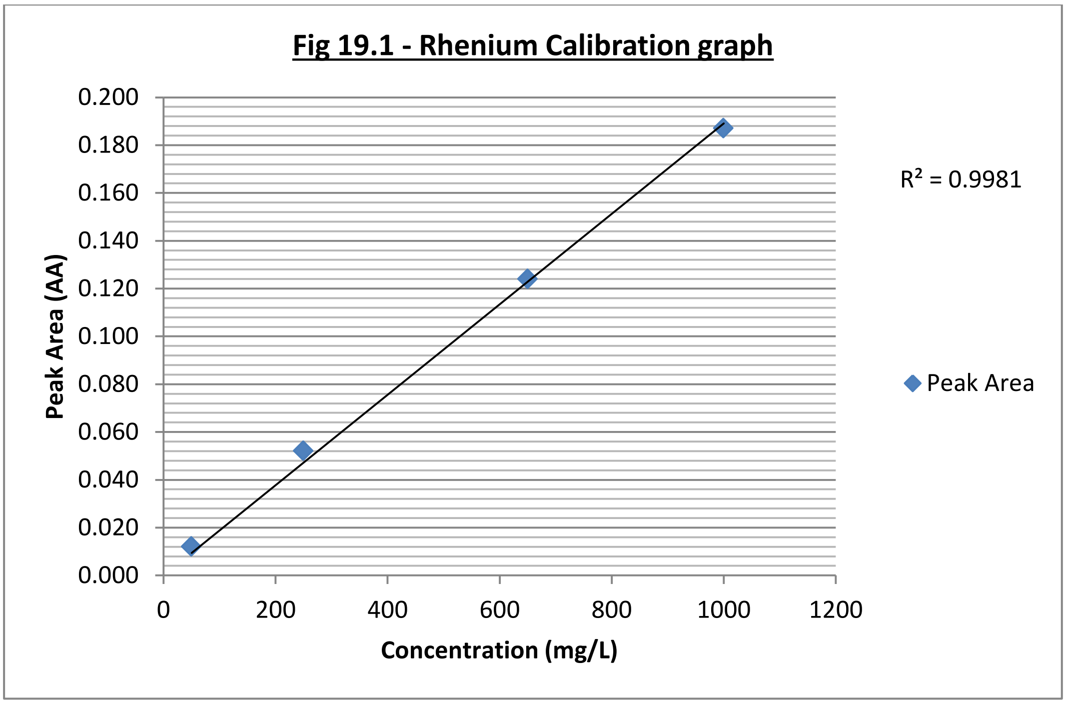
Fig.18 - rhenium from 5% aqua regia

3.1.7.2. Analytical Analysis

A calibration graph was produced using known concentrations of rhenium so than the concentration of the aqua regia rhenium samples could be calculated. Table 18 shows the concentrations used to create the calibration graph and the average peak areas that were generated by the AAS. Fig.19.1 shows the calibration graph that was created. To see the calibration raw data go to appendix 6a.

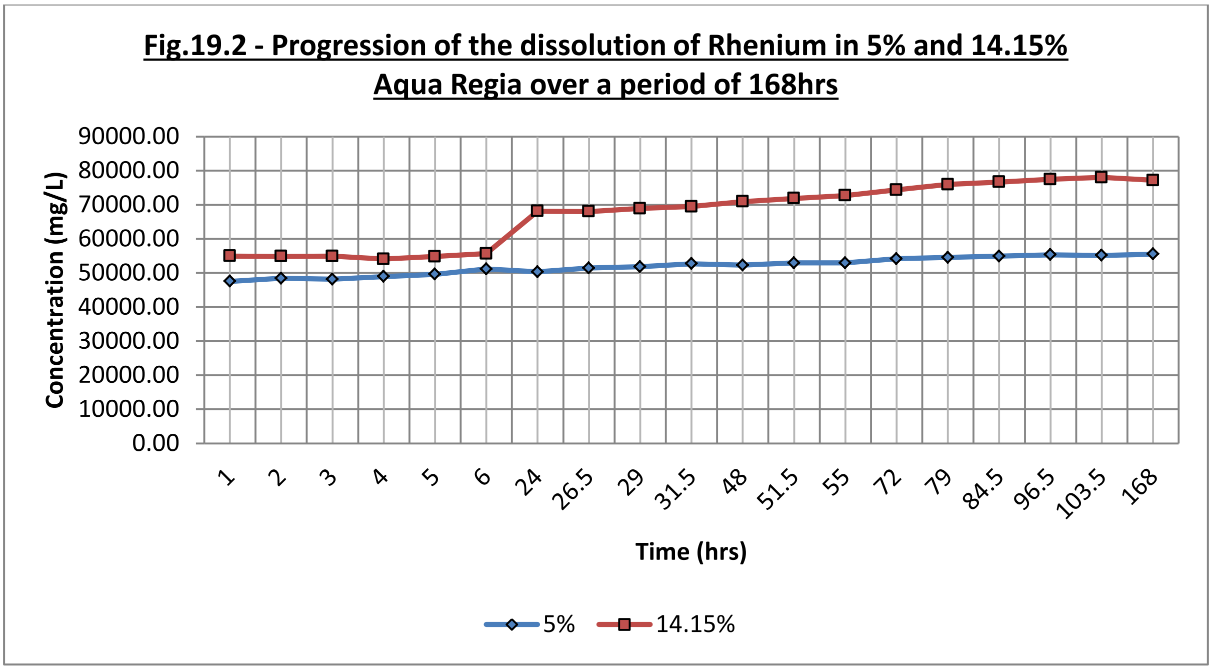
Table 18 - Peak Areas against known rhenium concentrations

| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 50 | 0.012 |
| 250 | 0.052 |
| 650 | 0.124 |
| 1000 | 0.187 |




The calibration graph shows that there is an extremely strong, positive linear regression as the $R^2$ value is 0.9981, which is only 0.0019 away from the value 1.

The AAS calculated the concentrations of all the rhenium samples using the data from table 18. All the samples had been diluted by a dilution factor of 1000, so to get the original concentration all the concentrations identified by the AAS had to be multiplied by 1000. To see the raw data of the rhenium samples go to appendix 6b.



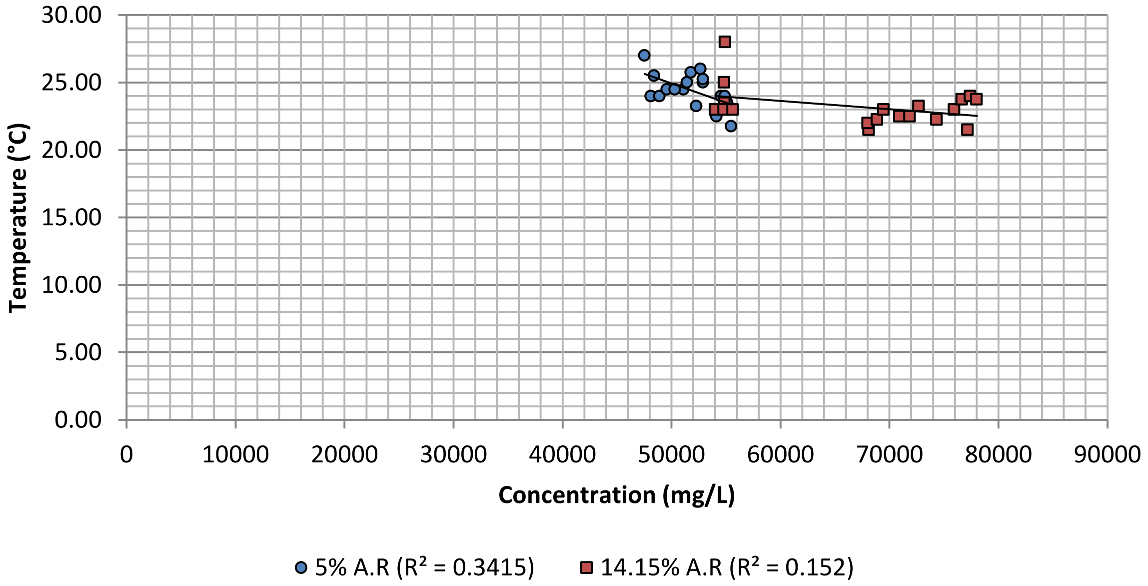

As Fig.19.2 shows, there is little change in the dissolution rate of rhenium in the 5% aqua regia solution. After one hour 47540mg/L had been dissolved and this only increased to 55506.67mg/L after 168 hours, which means there was only an increase of 7966mg/L of rhenium over a 168 hours period.

The 14.25% aqua regia had a slow dissolution rate for the first 6 hours of the experiment, with 54941.67mg/L being dissolved by hour 1 and only 55643.33mg/L being dissolved by hour 6. From hour 6 to hour 24 there is an increase of 12480mg/L of rhenium that had been dissolved. The dissolution rate increases steadily from hour 24 to hour 84.5 where the rate then plateaus.

### 3.1.7.3. Temperature

Looking at the temperatures against the concentrations of rhenium (Fig.19.3) both the 5% and 14.15% aqua regia samples have a weak negative linear regression. The 5% has an $R^2$ value of 0.3415 and the $R^2$ value for the 14.15% aqua regia is 0.152. Looking at the 14.15% aqua regia, the temperature does not change much, despite there being an increase in the amount of rhenium dissolved. At 55000mg/L the temperature is around 23°C and between 68000 - 78000mg/L the temperature ranges from 21 - 24°C which is not much of a difference. To look at the raw temperature data go to appendix 6c.

**Fig.19.3 - Comparison between concentration of dissolved Rhenium and Temperature in Aqua Regia (5% & 14.15%)**




### 3.1.8. Metal - Super Alloy, rhenium analysis

The super alloy was placed in the 23.3% aqua regia and after the experiment the AAS was used to try and identify the concentration of rhenium that had been dissolved from the super alloy.

#### 3.1.8.1. Observations

Table 19 - 23.3% Aqua Regia Observations for Super Alloy

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | dark orange, changed to green | smooth dull grey colour (fig.20a), bubbles coming off metal |
| 2 | dark green | surface white appearance, no bubbles |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | no change |
| 8 | no change | white surface (protective layer) crumbled off, exposing ridges on metal (fig.20b) |

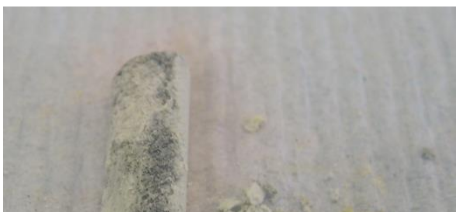


Fig.20a - Super alloy before going in aqua regia

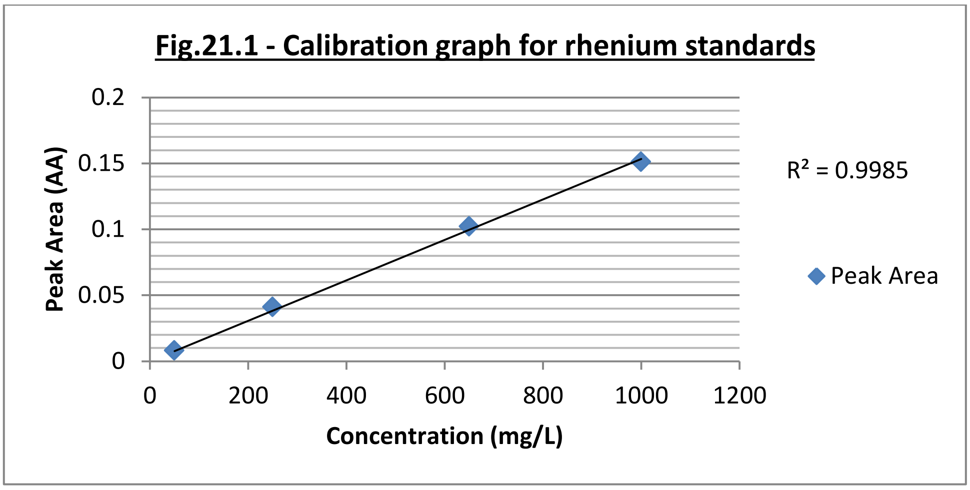
Fig.20b - Super alloy after being in 23.3% aqua regia

3.1.8.2. Analytical Analysis

A calibration graph was produced using known concentrations of rhenium and the peak areas were recorded. Table 20 shows the concentrations used and the average peak areas that were obtained from the AAS. Fig.21.1 shows the calibration graph. To see the calibration raw data go to appendix 7a.

Table 20 - Known concentrations against peak areas

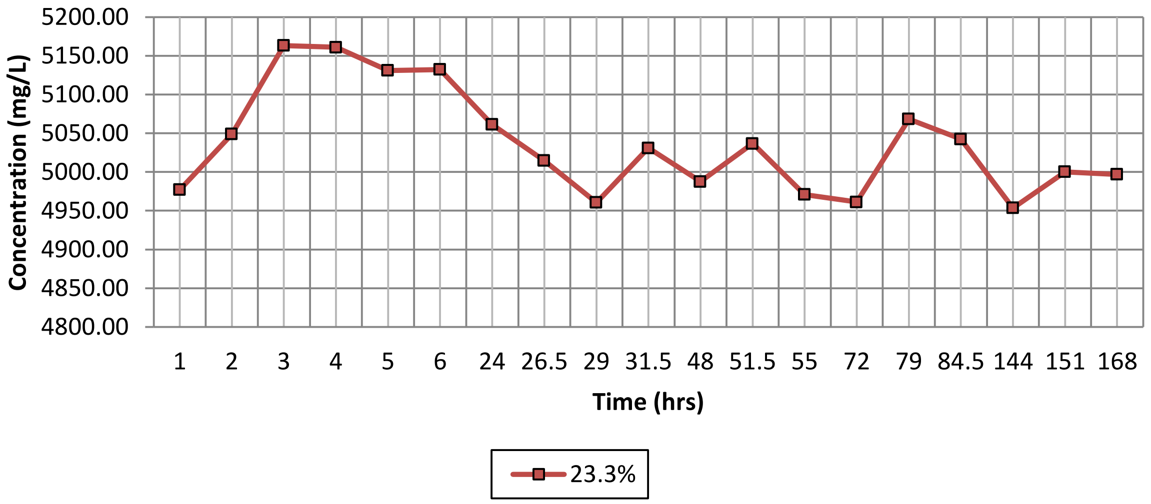
| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 50 | 0.008 |
| 250 | 0.041 |
| 650 | 0.102 |
| 1000 | 0.151 |




The calibration graph has an $R^2$ value of 0.9985 which indicates that there is a good positive linear regression and so all points almost fit perfectly on the line.

All the concentrations for the aqua regia rhenium samples were obtained by the AAS and were in mg/L. The samples were diluted by a dilution factor of 100, therefore, to get the original concentration all the samples were multiplied by 100. To see the raw data of the rhenium samples go to appendix 7b.

**Fig.21.2 - Progression of the dissolution of Rhenium (from super alloy) in 23.3% Aqua Regia over a period of 168hrs**

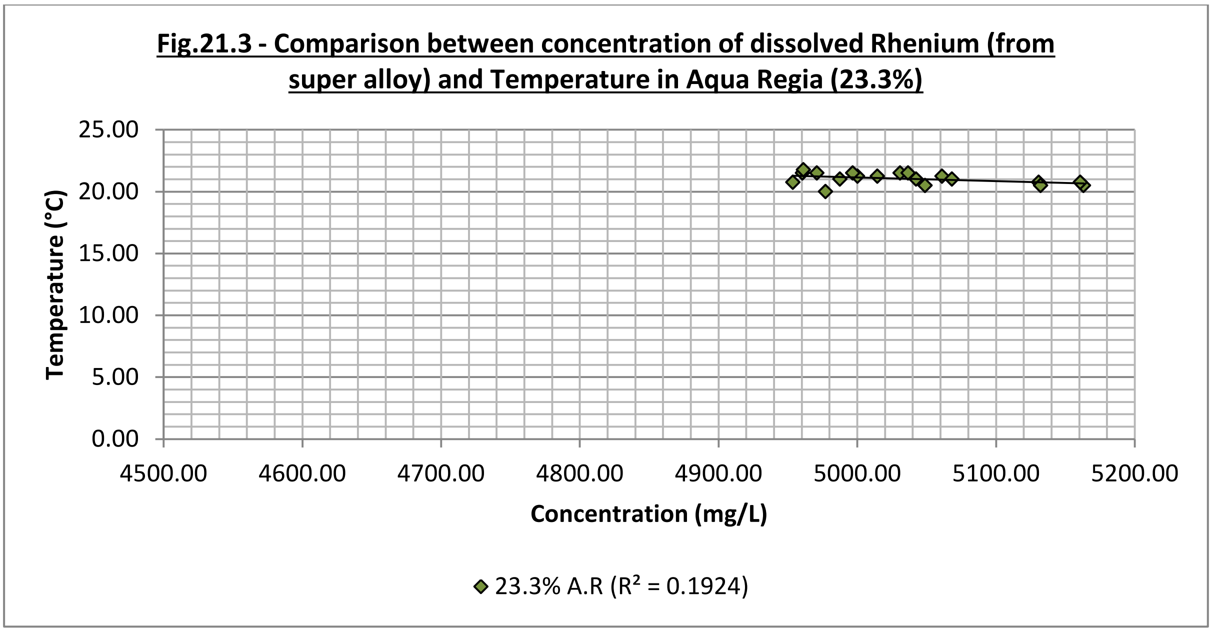



Looking at the dissolution of the rhenium in Fig.21.2 it is evident that there is a lot of fluctuation in the results. For example, by the first hour 4977.17mg/L of rhenium had been dissolved. This increases to 5163.33mg/L by hour 3 but then the amount of rhenium dissolved falls to 4960.67mg/L by hour 29 which would not be expected to happen. The rhenium was in solution with all the other dissolved metals from the super alloy and so this may have contributed to the fluctuation in results.

### 3.1.8.3. Temperature

It is evident by comparing the amount of rhenium being dissolved and the temperature of the aqua regia that there is no significant relationship between the two. Fig.21.3 shows that even though there is an increase in the amount of rhenium being dissolved, from 4960mg/L to 5160mg/L the temperature barely fluctuated. The temperature throughout the experiment was between 20°C and 22°C.

To look at the raw temperature data go to appendix 7c.




## 3.1.9. Metal - Tantalum

### 3.1.9.1. Observations

Table 21 - 5% Aqua Regia Observations for Tantalum

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | no change | no change |

Table 21 - 14.15% Aqua Regia Observations of Tantalum

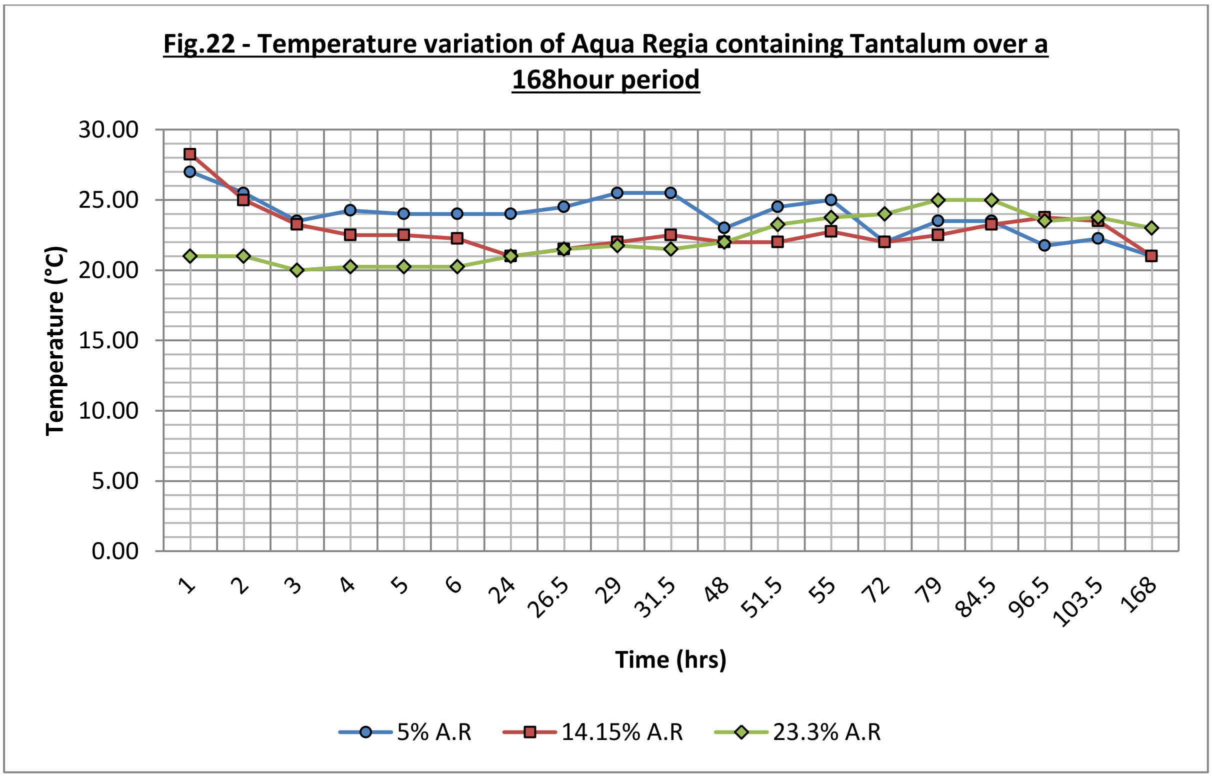
| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | light yellow | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | no change | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | clear | no change |

Table 21 - 23.3% Aqua Regia Observations for Tantalum

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | dark orange | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | light orange | no change |
| 6 | - | - |
| 7 | - | - |
| 8 | light yellow | no change |

3.1.9.2. Temperature

Looking at Fig.22 it shows that there was no real change in the temperature throughout the experiment for all three aqua regia strengths. The temperatures were extremely similar to that seen from the hafnium and like the hafnium; the 14.15% aqua regia had the highest temperature within the first hour (28.25°C), with 5% aqua regia next with a temperature of 27°C. The 23.3% aqua regia had a temperature of 21°C after the first hour.



### 3.1.10. Metal - Rhenium (ultra sonic method)

The ultra sonic bath was used in conjunction with the magnetic stirrers to investigate if the ultra sonic bath speeds up the dissolution process.

#### 3.1.10.1. Observations

5% Aqua Regia

During day one, rhenium debris was visible on the bottom of the beaker. On day two the solution was colourless, however after it had been in the ultra sonic bath, the solution had gone a grey colour (Fig.23a) as the agitation from the ultra sonic disturbed the debris at the bottom of the beaker. The grey eventually turned back to colourless as the rhenium debris settled to the bottom of the beaker (Fig.23b) again. This observation continued on day three and by day four the piece of rhenium had completely broken down and powder debris was the only thing left. By the end of day four the rhenium had completely dissolved.

14.15% Aqua Regia

On day one the colour of the aqua regia was light yellow and it stayed that colour throughout the experiment.

By day two there were some small deposits of rhenium at the bottom of the beaker and by day three the rhenium had completely broken down into powder form. On day four, the rhenium had almost completely dissolved and by day eight the rhenium had completely dissolved.


Fig.23a - aqua regia after ultra sonic bath

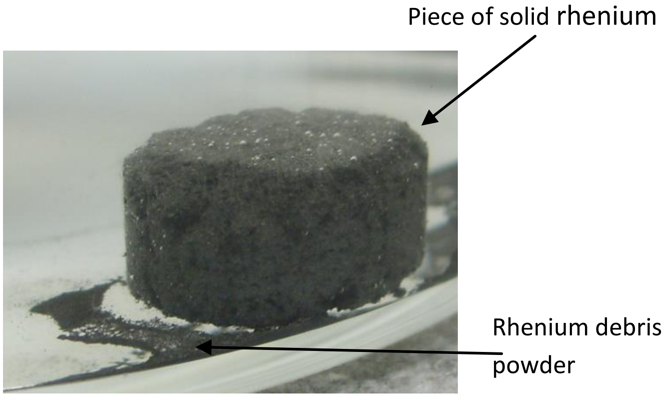


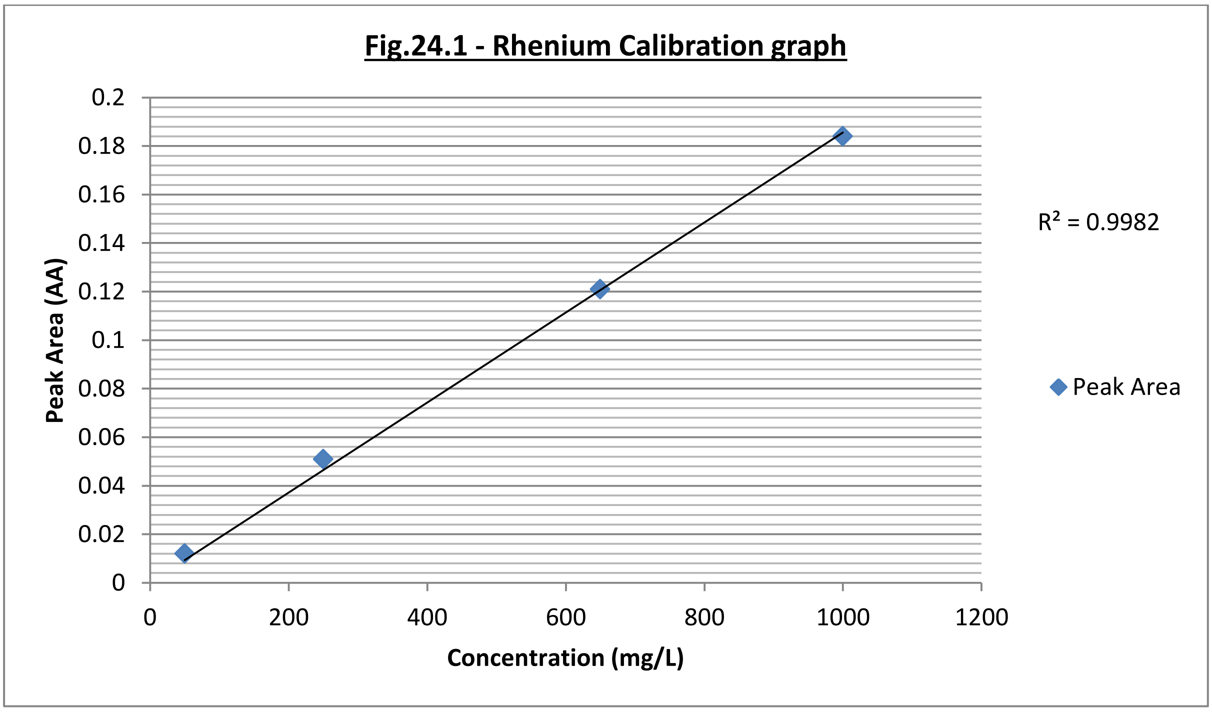

Fig.23b - rhenium deposit at bottom of beaker

### 3.1.10.2. Analytical Analysis

A calibration graph was created so the samples run on the AAS could have their concentrations calculated. Table 22 shows the known concentrations of rhenium used and average peak areas that were obtained by the AAS. Fig.24.1 is the calibration graph.
To see the calibration raw data go to appendix 8a.

Table 22 - Peak Areas against known concentrations of rhenium

| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 50 | 0.012 |
| 250 | 0.051 |
| 650 | 0.121 |
| 1000 | 0.184 |




The calibration graph indicates that there is a strong positive linear regression as the $R^2$ value is 0.9982 which is extremely close to the value of 1.
All the samples had their concentrations calculated by the AAS and were measured in mg/L. All the samples had a dilution factor of 1000, so all samples obtained by the AAS were multiplied by 1000 to get the original concentration. To see the raw data of the rhenium samples go to appendix 8b.

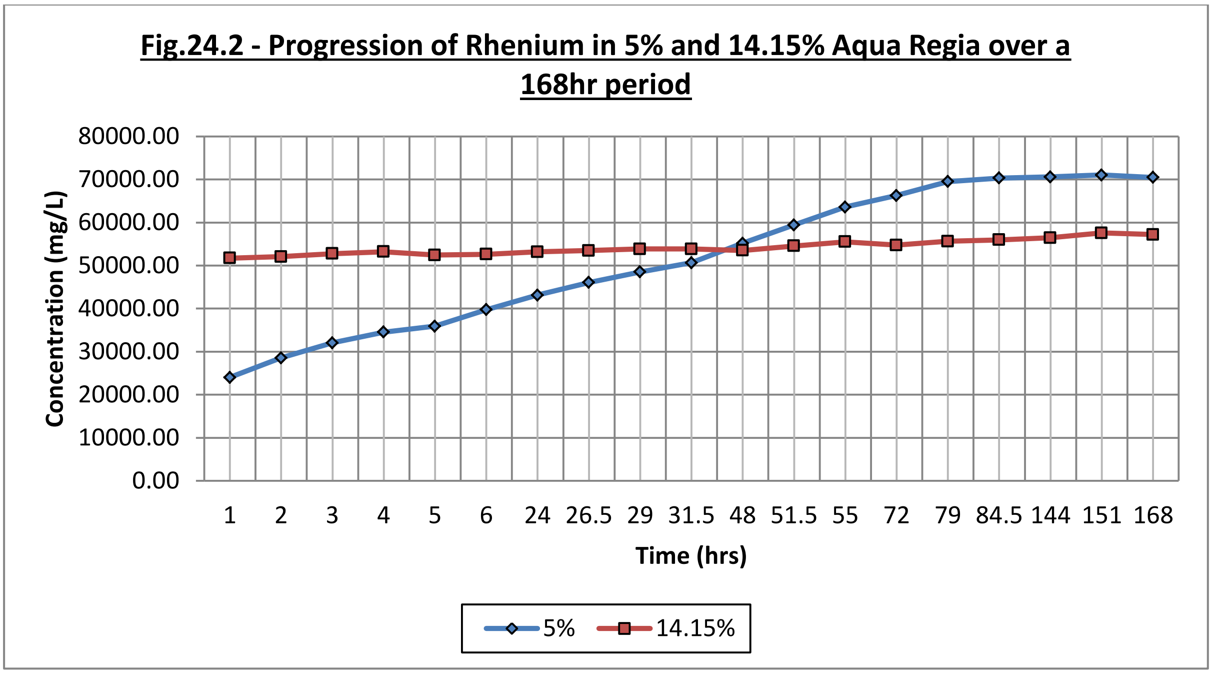



Fig.24.2 shows that throughout the 168hours the amount of rhenium detected by the AAS for the 14.15% aqua regia does not change apart from the slight increase from hours 144 to 168. The amount of rhenium dissolved in the 14.15% aqua regia goes from 51716.67mg/L by hour 1 up to 57180.00mg/L by hour 168.

The 5% aqua regia has a steady increase in the dissolution rate of the rhenium from hour 1 up to hour 79 where it eventually plateaus off. The amount of rhenium dissolved in the 5% solution went from 24008.34mg/L by hour 1 up to 69503.33mg/L by hour 79, with the final concentration of rhenium after 168 hours being 70465.00mg/L.

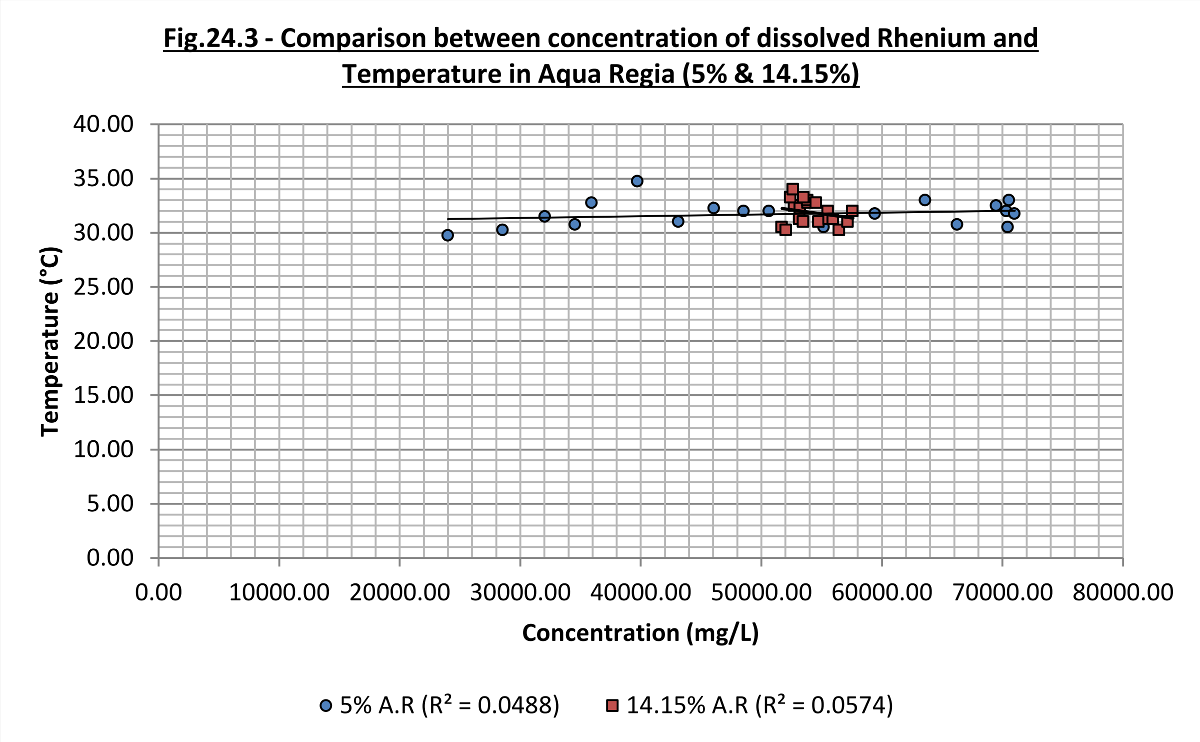
3.1.10.3. Temperature

Observing Fig.24.3 shows that the temperature of both solutions was higher than previously seen on any other metal dissolution. This was probably due to the use of the ultra sonic bath. The temperatures range from 30 - 35°C and despite the 5% aqua regia increasing the dissolution rate over time, there does not appear to be any increase in the temperature.

The 14.15% aqua regia samples are al clustered together and have a temperature range of 30 - 34°C.

Both the 5% and 14.15% aqua regia have extremely low $R^2$ values (0.0488 and 0.0574 respectively) which indicate that there is an extremely weak linear regression.

To look at the raw temperature data go to appendix 8c.




### 3.1.11. Metal - Tungsten

3.1.11.1. Observations

Table 23a - 5% Aqua Regia Observations for Tungsten

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | no change |
| 2 | no change | no change |
| 3 | no change | tiny amount of precipitate on bottom of beaker |
| 4 | no change | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | no change |
| 8 | no change | precipitate dissolved |

Table 23b - 14.15% Aqua Regia Observations for Tungsten

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | pale yellow | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | no change |
| 8 | no change | no change |

Table 23c - 23.3% Aqua Regia Observations for Tungsten

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | red | bubbles coming off metal |
| 2 | orange | no bubbles |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | cloudy yellow | metal and beaker covered in yellow precipitate (fig.25a + 25b) |
| 8 | no change | no change |

Fig.25a - Precipitate in 23.3% aqua regia

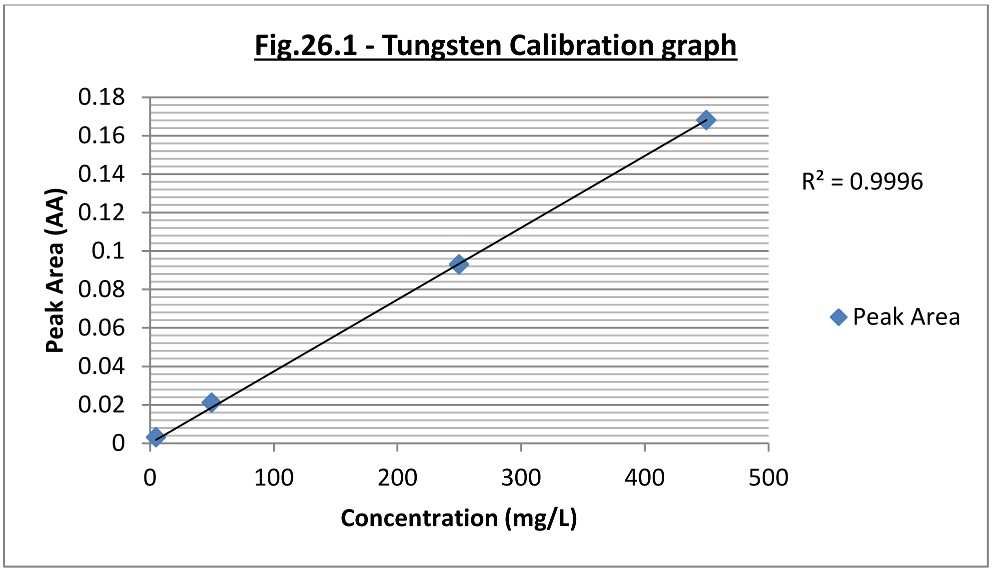
Fig.25b - Yellow coating on tungsten once removed from aqua regia

3.1.11.2. Analytical Analysis

Table 24 shows the tungsten standards used and the average peak areas obtained by the AAS which were used to create a calibration graph (Fig.26.1). To see the calibration raw data go to appendix 9a.

Table 24 - Peak Area against known tungsten concentrations

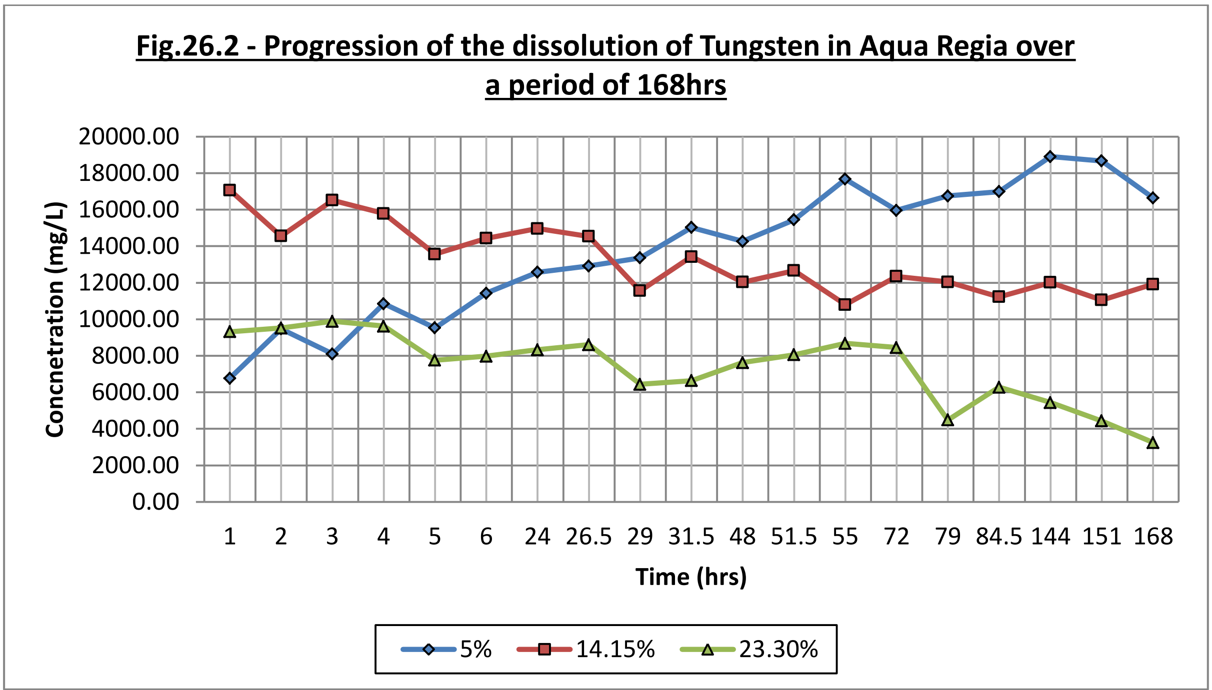
| Concentration (mg/L) | Peak Area (AA) |
|---|---|
| 5 | 0.003 |
| 50 | 0.021 |
| 250 | 0.093 |
| 450 | 0.168 |




It is clear to see that the calibration graph has an extremely good, positive linear regression as all points fit almost perfectly onto the line. This is supported by the fact that the $R^2$ value is 0.9996 which is extremely close to the desired value of 1.

The AAS used the calibration graph to calculate the concentrations for all the tungsten samples. All the samples were calculated in mg/L and because they all had a dilution factor of 1000, the AAS results had to be multiplied by 1000.

To see the raw tungsten data go to appendix 9b.



The results from Fig.26.2 are interesting as the 5% aqua regia indicates that although there is some fluctuation in the concentration of tungsten there is a trend that the amount of tungsten dissolved increased over the 168 hours period. This contradicts the observation made that there was no noticeable change to the condition of the metal.
Furthermore, both the 14.15% and 23.3% aqua regia had a slight negative trend in that the amount of tungsten that was being dissolved actually decreased. You would expect to see the results either plateau or increase, but not decrease. Due to the little amount of tungsten that dissolved, it is plausible that what is being observed is noise from the AAS rather than a sample result as the concentrations of tungsten being analysed would have been below the ppm limit of detection.

#### 3.1.11.3. Statistical Analysis

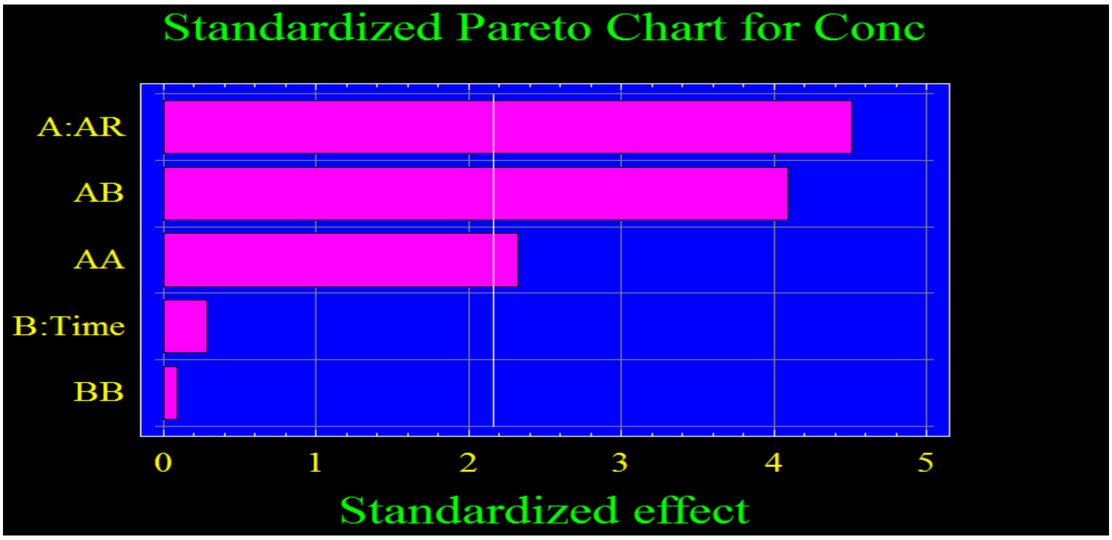
Some of the samples that were run on the AAS were used in the statistical software in order to carry out some statistical analysis on the dissolution of tungsten in aqua regia.
The samples were all of original concentration and the averages of the samples were used. Table 15 shows the concentrations of the samples used.

Table 25 - Concentrations of samples used in statgraphic software

| | 5% Aqua Regia | 14.15% Aqua Regia | 23.3% Aqua Regia |
|---|---|---|---|
| Time (hrs) | Concentration (mg/L) | | |
| 1 | 5419.67 | 16763.33 | 9686.33 |
| 1 (replica) | 8117.00 | 17363.33 | 8953.00 |
| 84.5 | 17386.67 | 11823.33 | 6271.00 |
| 84.5 (replica) | 16590.00 | 10334.33 | 6289.67 |
| 84.5 (replica) | - | 10508.33 | - |
| 84.5 (replica) | - | 12253.33 | - |
| 168 | 16723.33 | 11873.33 | 3641.67 |
| 168 (replica) | 16560.00 | 11960.00 | 2856.67 |

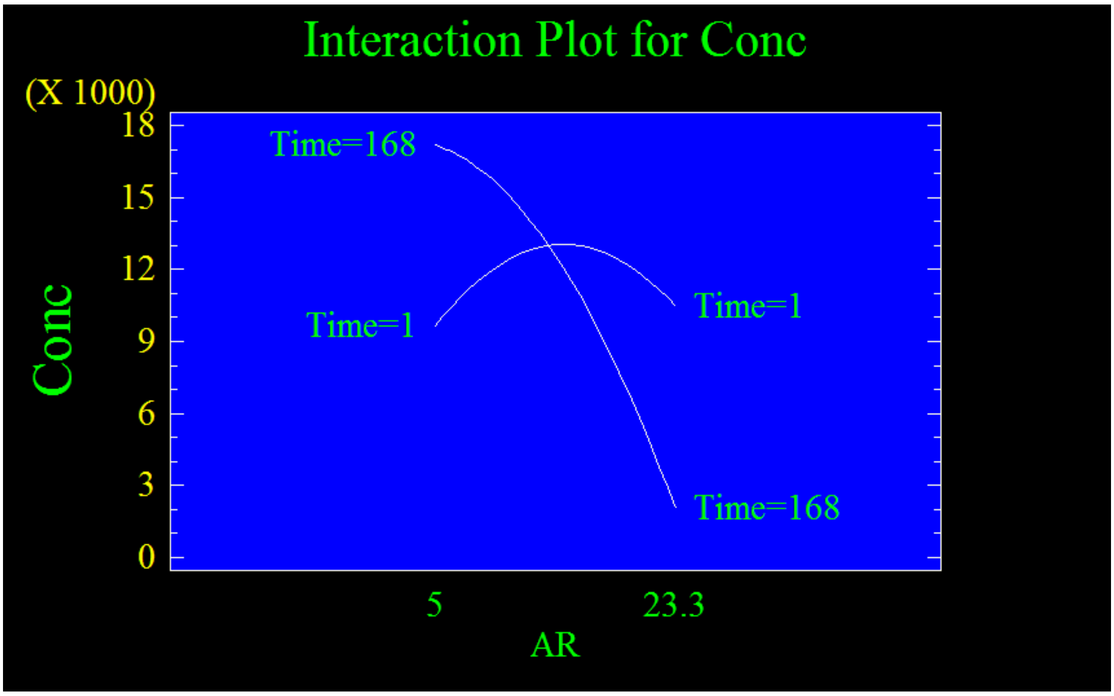
The standardized pareto chart for the concentration of tungsten (Fig.26.3) indicates that aqua regia (A) is the most significant effect in the effectiveness on the dissolution of tungsten. Surprisingly even though both the time (B) and the interaction of time (BB) are both indicated as being insignificant as they are below the white line, the interaction between aqua regia and time (AB) is the second most significant factor in the dissolution of tungsten. The interaction of just aqua regia (AA) is only just a significant effect as it only just passes the white line.

Fig.26.3 - Standardized Pareto Chart for Concentration of Tungsten




Legend: Conc = Concentration (mg/L); A:AR = Aqua regia (%); B:Time (hrs); AB = Aqua regia:Time; AA = Aqua reiga:aqua regia BB = Time:time

Fig.26.4 - Interaction Plot for Concentration of Tungsten

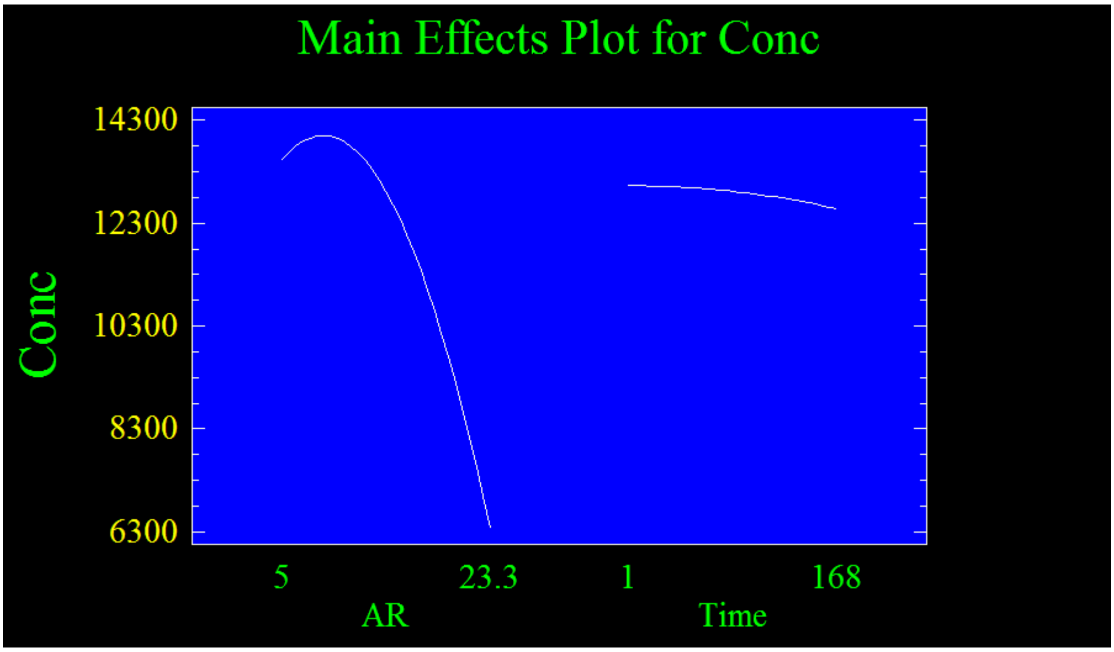



Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The interaction plot for the concentration of tungsten (Fig.26.4) suggest that at 1 hour into the experiment both the 5% and 23.3% aqua regia will have dissolved around the same amount of tungsten, with the 5% dissolving 9000mg/L and the 23.3% dissolving 10000mg/L. Fig.26.4 also indicates that the 14.15% aqua regia (which is half way between the strength of 5% and 23.3%) will dissolve much more tungsten in the first hour than the other two concentrations, with 13000mg/L being dissolved.
The interaction plot shows that when the 5% aqua regia reaches 168 hours, the concentration of tungsten in solution has increased to 17000mg/L. The 23.3% aqua regia shows the complete opposite, with the concentration of tungsten dropping down to 2000mg/L by the time it reaches the end of the experiment (168 hours).

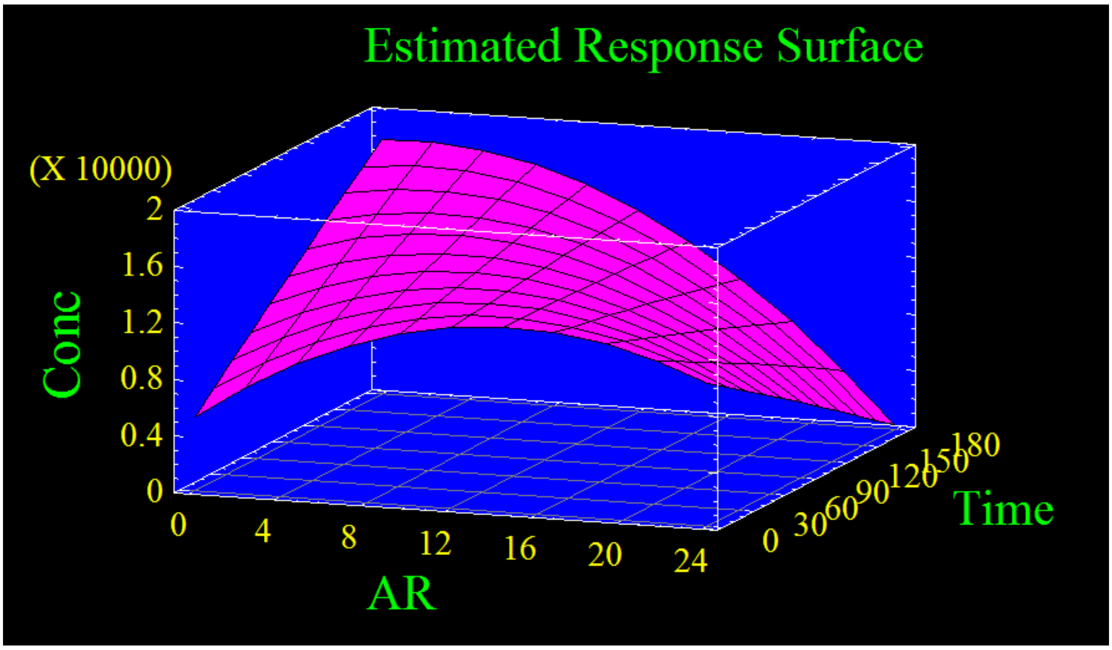
The main effects plot for the concentration of tungsten (Fig.26.5) shows that the 5% aqua regia (AR) has a positive effect on the concentration of tungsten being dissolved as the plot suggests 13300mg/L could be dissolved. As the strength of aqua regia increases to 23.3% the amount of tungsten that gets dissolved is reduced dramatically and when 23.3% aqua regia is reached, only 6300mg/L of tungsten is dissolved in solution.
The time plot shows that there is not much of a difference in the concentration of tungsten from the first hour to 168 hours, with just a slight drop in the concentration of tungsten as time progressed.

Fig.26.5 - Main Effects Plot for Concentration of Tungsten




Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

Fig.26.6 - Estimated Response Surface of Tungsten



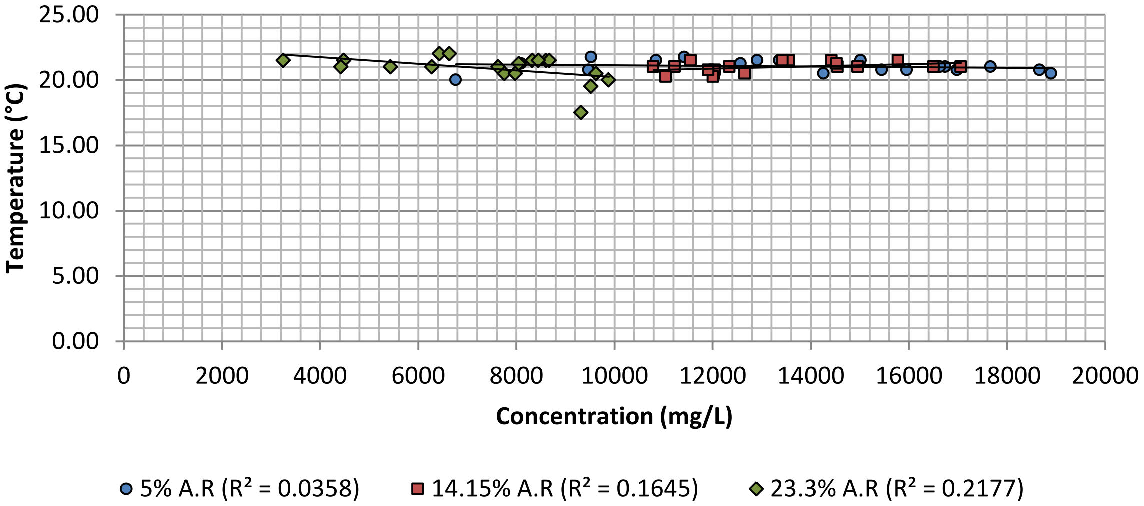

Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The estimated response surface (Fig.26.6) shows that when a low strength of aqua regia is used (between 4 - 1%) the dissolution rate of tungsten increases steadily for the duration of the experiment. At 1% aqua regia, Fig.26.6 estimates that 7000mg/L of tungsten would be dissolved in the first hour and this would increase to 18000mg/L by the end of the time. Fig.25.6 also shows that as higher strengths of aqua regia, from 16 - 24% are used, the concentration of tungsten is higher than the lower strengths of aqua regia within the first hour, but as time progresses, the concentration of tungsten decreases. The decrease is in the concentration of tungsten becomes more severe as the strength of aqua regia reaches 24%.

### 3.1.11.4. Temperature

Fig.26.7 has a trend that shows that the temperatures stay very similar even with the different concentrations of tungsten. The 5% and 14.15% aqua regia solutions have temperatures around 20 - 22°C despite the concentrations of tungsten ranging from 6400mg/L up to 18500mg/L. The 23.3% aqua regia has similar temperatures to that of the 5% and 14.15% aqua regia, with the slight difference that three of the temperatures are slightly lower than the rest, at 17 - 20°C. To see the raw temperature data go to appendix 9c.

**Fig.26.7 - Comparison between concentration of dissolved Tungsten and Temperature in Aqua Regia (5%, 14.15% & 23.3%)**



### 3.1.12. Metal - Titanium

#### 3.1.12.1. Observations

Table 26a - 5% Aqua Regia Observations for Titanium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | clear | no change |
| 2 | no change | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | no change |
| 8 | no change | no change |

Table 26b - 14.15% Aqua Regia Observations for Titanium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | light orange | no change |
| 2 | light yellow | no change |
| 3 | no change | no change |
| 4 | no change | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | no change | no change |
| 8 | clear | no change |

Table 26c - 23.3% Aqua Regia Observations for Titanium

| Day | Solution colour | Metal appearance |
|---|---|---|
| 1 | red | bubbles in solution, not coming off metal |
| 2 | gold | no bubbles |
| 3 | light orange | no change |
| 4 | pale orange | no change |
| 5 | - | - |
| 6 | - | - |
| 7 | pale yellow | no change |
| 8 | no change | no change |

#### 3.1.12.2. Analytical Analysis

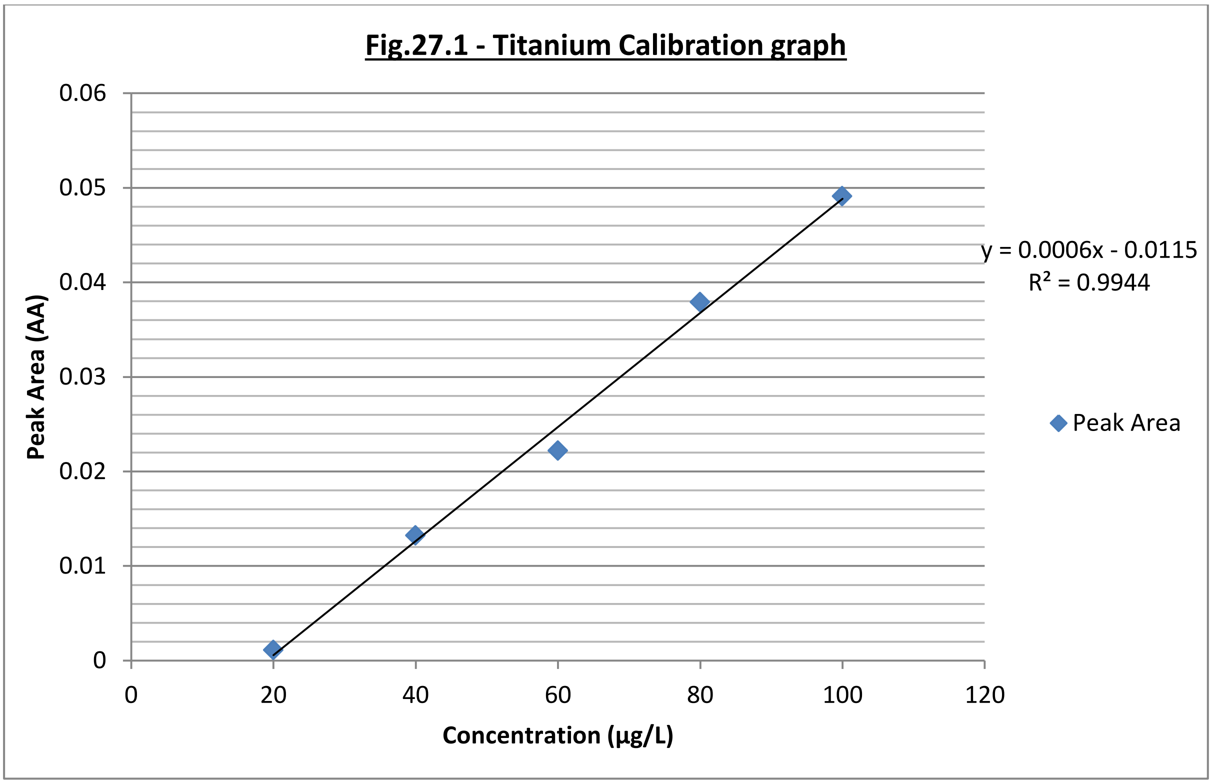
A calibration graph was created using known standards of titanium against peak area averages which were obtained by the AAS. Table 26 shows the concentrations used and the peak areas that correspond. Fig.27.1 shows the created calibration graph.

To look at the raw calibration data go to appendix 10a.

Table 27 - Known titanium concentrations and Peak Areas

| Concentration (ppb) | Peak Area (AA) |
|---|---|
| 20 | 0.0011 |
| 40 | 0.0132 |
| 60 | 0.0222 |
| 80 | 0.0379 |
| 100 | 0.0491 |

Fig.27.1 shows that there is a very strong positive linear regression as four of the five points are extremely close to fitting on the straight line. This is supported by the $R^2$ value which is 0.9944 which is close to the value of 1.




By using the equation y = 0.0006x - 0.0115 it was possible to calculate the concentrations of titanium that was dissolved in the aqua regia.

Before the concentrations could be calculated the equation needed to be re-arranged so that 'x' became the subject.

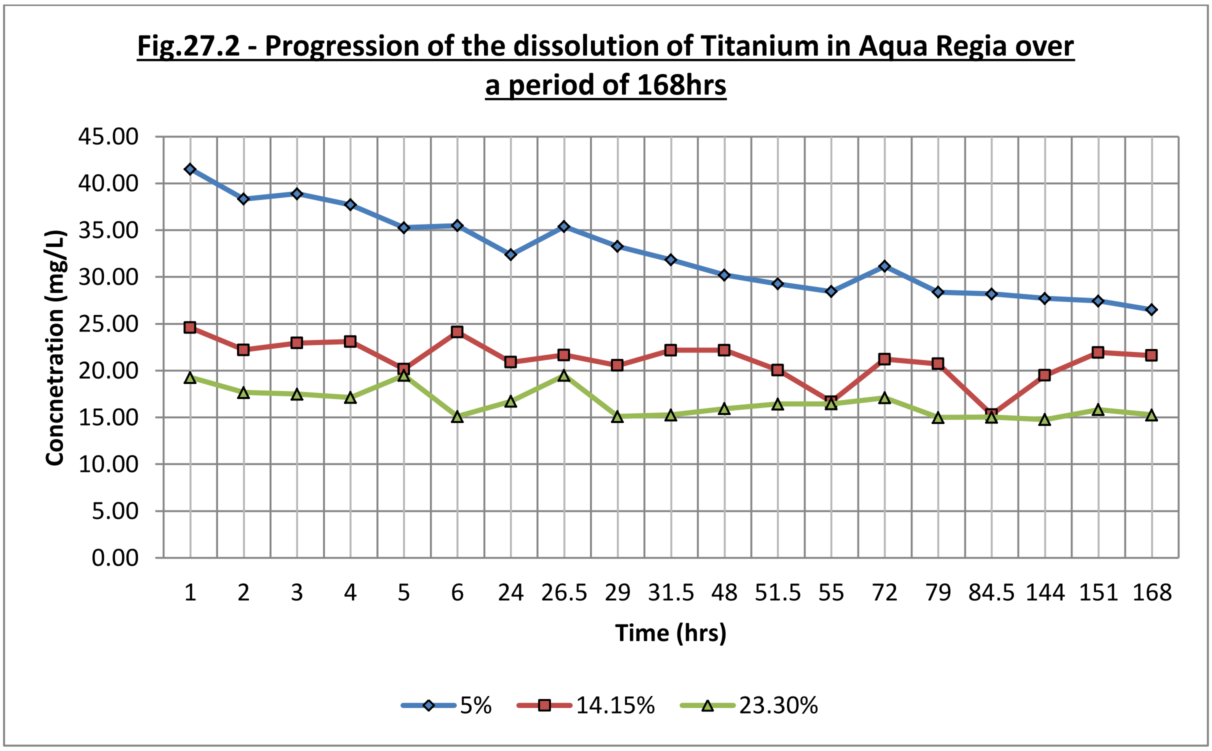
The equation was re-arranged as follows:

$$x = \frac{(y + 0.0115)}{0.0006}$$

Where y = peak area and x = concentration of titanium in µg/L

The samples were measured in µg/L however they needed to be changed into mg/L. For this to be achieved all the 'x' values were divided by 1000.
All the samples had a dilution factor of 1000, therefore to get the original concentration all the AAS results were multiplied by 1000.

Fig.27.2 shows that the 5% aqua regia had the highest concentration of titanium after the first hour, with 41.53mg/L being dissolved compared to 24.59mg/L and 19.28mg/L from the 14.15% and 23.3% aqua regia respectively. The concentration of the titanium decreased as time progressed with the 5% aqua regia, whereas the trend for the 14.15% and 23.3% aqua regia was that the concentration of titanium seemed to plateau (with slight fluctuations throughout). It is not expected to see a decrease in the concentration of titanium as time progresses. None of the titanium dissolved, therefore it can be concluded that the results observed was noise from the AAS rather than a true result. To see the raw data go to appendix 10b.




### 3.1.12.3. Statistical Analysis

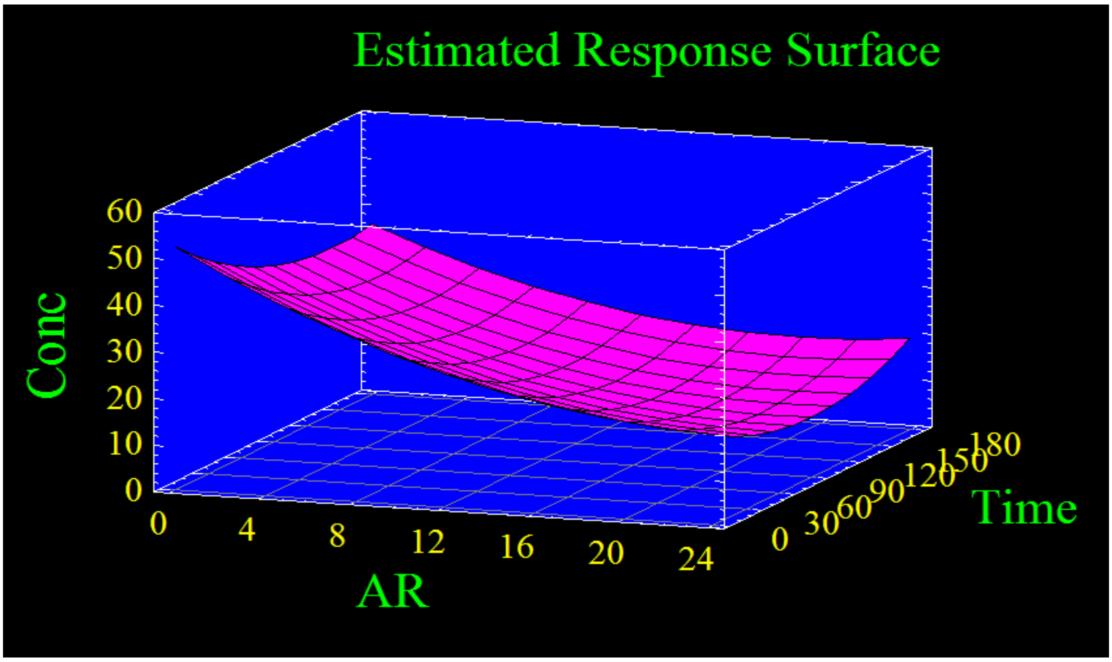
The statgraphic software picked the samples that were to be used to produce statistical analysis. The averages of the samples were used and they were converted from µg/L into mg/L. Table 27 shows the concentrations of the samples used.

Table 28 - Concentrations of titanium samples used in statgraphic software

| | 5% Aqua Regia | 14.15% Aqua Regia | 23.3% Aqua Regia |
|---|---|---|---|
| Time (hrs) | Concentration (mg/L) | | |
| 1 | 43.50 | 25.00 | 19.56 |
| 1 (replica) | 39.56 | 24.17 | 19.00 |
| 84.5 | 28.78 | 20.66 | 14.39 |
| 84.5 (replica) | 27.61 | 18.22 | 15.67 |
| 84.5 (replica) | - | 9.83 | - |
| 84.5 (replica) | - | 12.50 | - |
| 168 | 25.83 | 19.61 | 12.56 |
| 168 (replica) | 27.17 | 23.61 | 18.00 |

The estimated response surface (Fig.27.3), like the tungsten graph, shows that the lower the strength of aqua regia used, the better the dissolution rate. For example, 1% aqua regia would have a concentration of 52mg/L after the first hour compared to 24% aqua regia which would have a concentration of 20mg/L. The shape seems to be the same throughout, with the dissolution rate highest at the beginning, and then it starting to decrease as time progresses, with it slowly increasing again as the time reaches 180 hours.

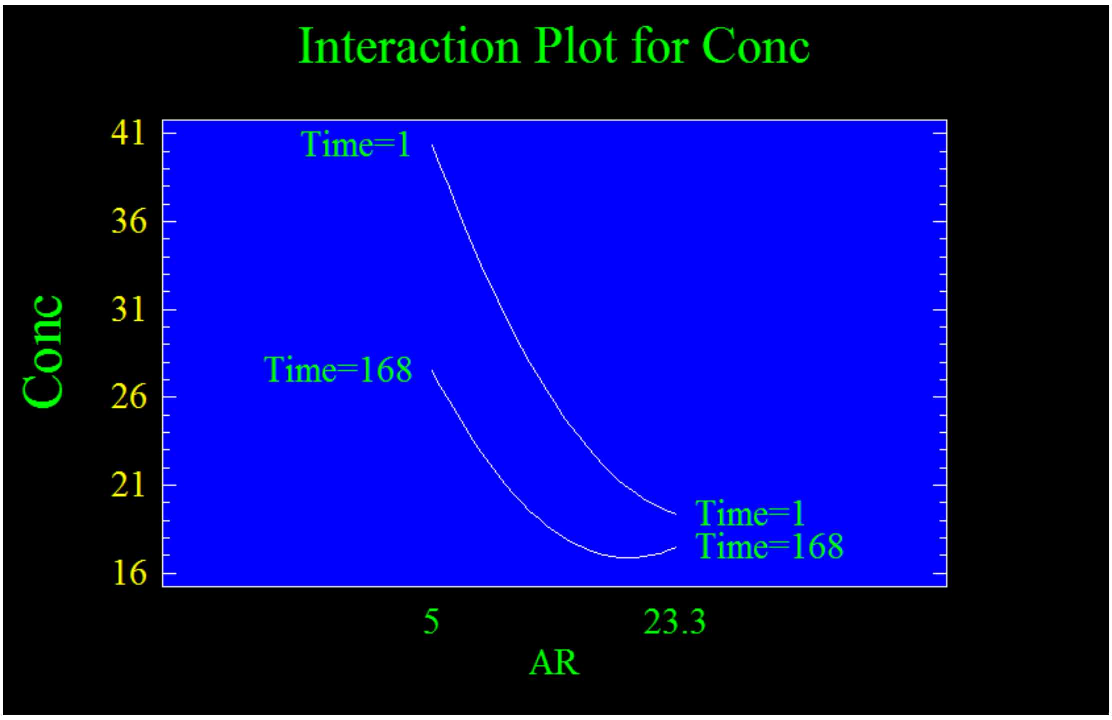
Fig.27.3 - Estimated Response Surface of Titanium




Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

The interaction plot for the concentration of titanium (Fig.27.4) shows that when 5% aqua regia is used, the most amount of titanium will be dissolved in the first hour (with 40mg/L being dissolved). This decreases as time goes on until 168 hours is reached and then the concentration of titanium in the 5% aqua regia has fallen to 26mg/L. As the strength of aqua regia increases, the difference between the concentration of titanium from the first hour to 168 hours decreases slowly. Once 23.3% aqua regia is reached, the difference between hour 1 and hour 168 is rather small. In the first hour 19mg/L is dissolved, whereas, by hour 168, only 17mg/L of titanium is dissolved.

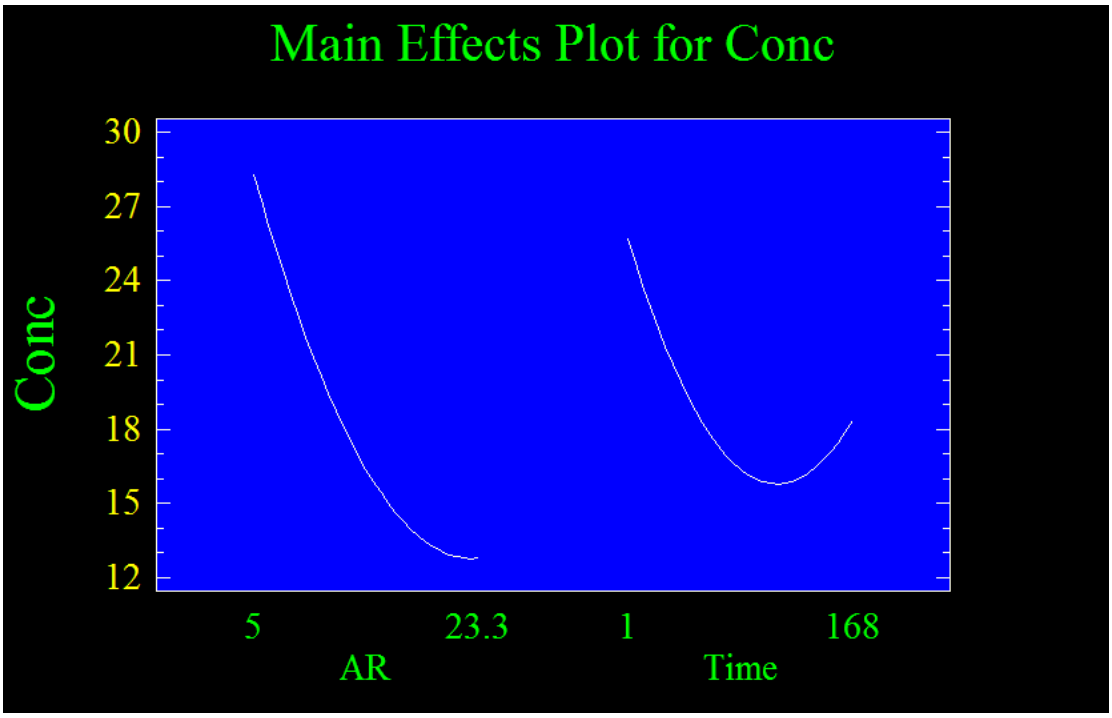
Fig.27.4 - Interaction Plot for Concentration of Titanium




Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

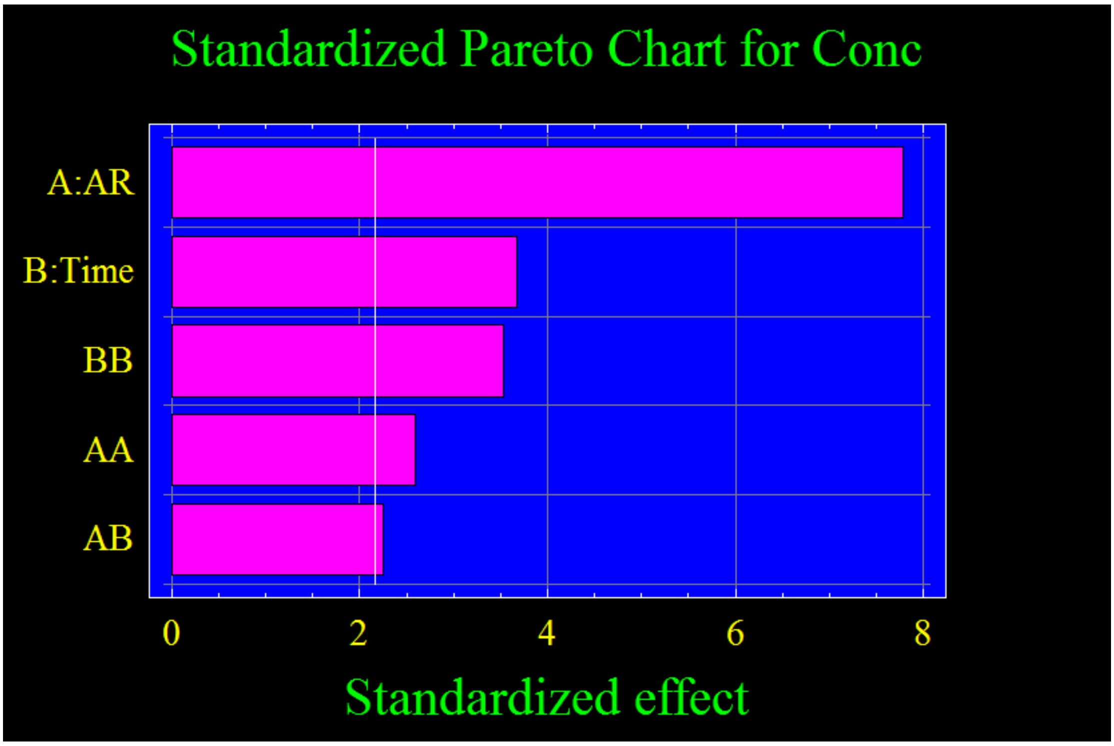
The main effects plot for the concentration of titanium (Fig.27.5) shows that the 5% aqua regia and the first hour in the dissolution process is the most significant time in dissolving titanium. 28mg/L of titanium is dissolved using 5% aqua regia and 25mg/L is dissolved in the first hour of the process. As the strength of aqua regia increases, the dissolution of titanium decreases dramatically with only 13mg/L being dissolved with 23.3% aqua regia. As time progresses, the dissolution starts to drop but then the amount of titanium being dissolved starts to increase again as time reaches 168 hours.

Fig.27.5 - Main Effect Plot for Concentration of Titanium




Legend: Conc = Concentration (mg/L); AR = Aqua regia (%); Time (hrs)

Fig.27.6 - Standardized Pareto Chart for Concentration of Titanium



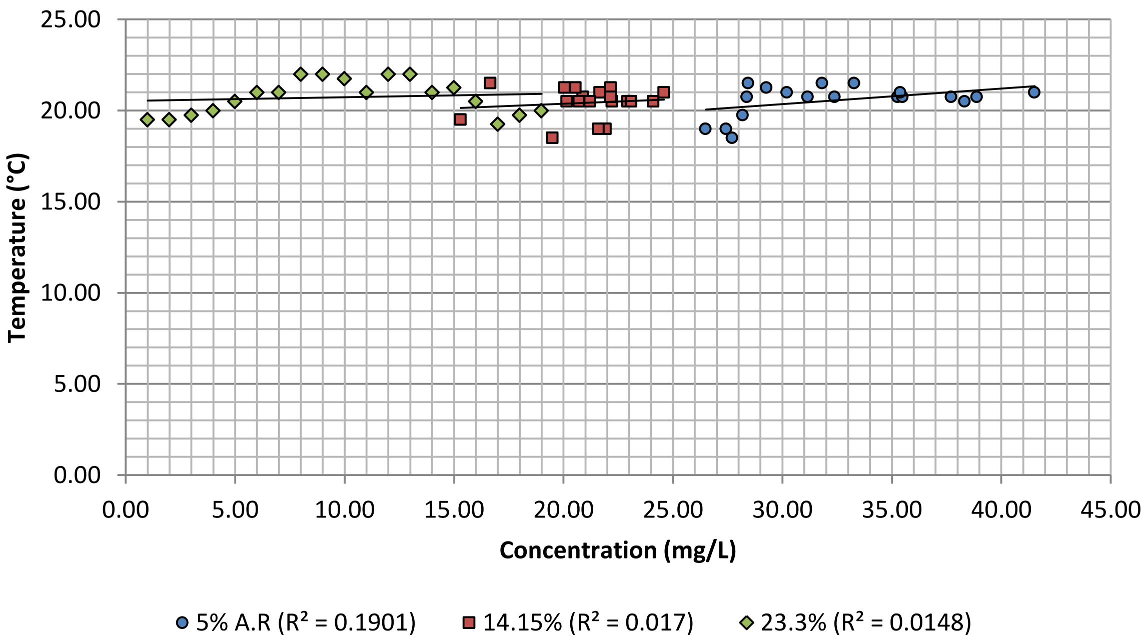

Legend: Conc = Concentration (mg/L); A:AR = Aqua regia (%); B:Time (hrs); AB = Aqua regia:Time; AA = Aqua reiga:aqua regia BB = Time:time

The standardized pareto chart for the concentration of titanium (Fig.27.6) indicates that all the interactions are significant, with aqua regia (A) being by far the most significant effect in the dissolution of titanium. The interaction being aqua regia and time (AB) is the least significant factor, followed by the interaction between aqua regia (AA). Time (B) is the second most significant effect in the dissolution of titanium.

### 3.1.12.4. Temperature

Looking at the comparison between the temperature and the concentration of titanium (Fig.27.7) it is evident that there is no correlation between the two. The vast majority of the temperatures as between 19 - 22°C and this is despite the concentrations of titanium ranging from 1 - 42mg/L. If there was correlation between the two it would be expected to see that as the temperature increased, so did the concentration of titanium.
The $R^2$ values indicate that there is an extremely weak linear regression as the values for the 5%, 14.15% and 23.3% aqua regia are 0.1901, 0.017 and 0.0148 respectively. To see the temperature raw data go to appendix 10c.

**Fig.27.7 - Comparison between concentration of dissolved Titanium and Tenperature in Aqua Regia (5%, 14.15% & 23.3%)**



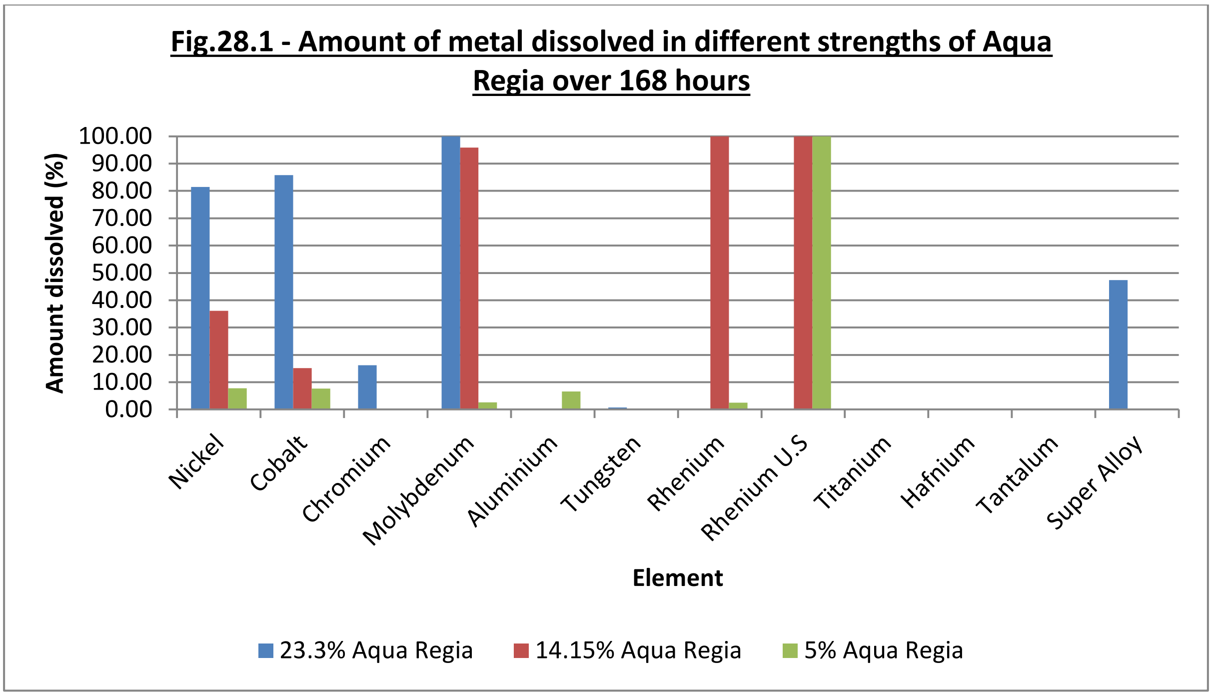
### 3.2. Weights of the metals

All the metals that were used in the aqua regia experiment were weighed at the beginning before they were placed into the aqua regia and then weighed again after the 168 hours was over.

Table 29 shows the calculated weight loss, in percentage, of all the metals tested. Fig28.1 is a visual representation of the data found in table 29. To see the raw data of the start and end weights of the metals go to appendix 11.

Table 29 – Percentage difference of the total weight loss

| | Aqua Regia | | |
|---|---|---|---|
| Element | 23.30% | 14.15% | 5% |
| Nickel | 81.45% | 36.13% | 7.81% |
| Cobalt | 85.82% | 15.18% | 7.73% |
| Chromium | 16.19% | 0.01% | 0.01% |
| Molybdenum | 100% | 95.88% | 2.58% |
| Aluminium | - | - | 6.67% |
| Tungsten | 0.81% | 0.19% | 0.08% |
| Rhenium | - | 100% | 2.47% |
| Rhenium U.S | - | 100% | 100% |
| Titanium | 0.00% | 0.00% | 0.00% |
| Hafnium | 0.01% | 0.00% | 0.01% |
| Tantalum | 0.00% | 0.00% | 0.00% |
| Super Alloy | 47.41% | - | - |




As Fig.28.1 shows, the 23.3% aqua regia seemed to dissolve most of the different metals. Molybdenum dissolved the most, with 100% of the metal being dissolved in 23.3% aqua regia. Nickel and cobalt dissolved almost the same amount in 23.3% aqua regia, with the total weight loss being 81.45% and 85.82% respectively. Only a small amount of chromium was dissolved, even in the 23.3% aqua regia, with only 16.19% total weight loss. For nickel and cobalt, the effectiveness of the aqua regia reduced significantly when the 14.15% and 5% aqua regia were used. The effectiveness of the 5% aqua regia on the nickel and cobalt was very similar, with 7.81% of nickel being dissolved and 7.73% cobalt dissolved. Molybdenum reacted differently to the 14.15% aqua regia compared to the nickel, cobalt and chromium with 65.88% of the molybdenum managing to dissolve. Like the other metals though, the 5% aqua regia was not very effective at dissolving molybdenum with only 2.58% weight loss.

Even though both the rhenium and rhenium (using ultra sonic bath) were not tested in the 23.3% aqua regia, they both were completely dissolved in the 14.15% solution. There was a large difference to the effectiveness of the 5% aqua regia. The rhenium which just used magnetic stirring throughout only dissolved 2.47% of the rhenium, whereas, the rhenium which used ultra-sonic bath in addition to magnetic stirring, dissolved 100% of the metal. 47.41% of the super alloy got dissolved in 23.3% aqua regia. As mentioned in the observations, a coating had formed on the super alloy which probably halted the dissolution further. From these results, it is evident that tungsten is barely affected by the effects of aqua regia and titanium, hafnium and tantalum do not dissolve in aqua regia.

### 3.2.1. Percentage Errors

The concentration calculated for the metals at the end of the experiment (168 hours) from the atomic absorption spectroscopy were used against the weight difference calculated from weighing the metals at the start and end of the experiment to work out the percentage error of the AAS result. Working out the percentage error is important to see how accurate the analytical results are compared to the true value.

Before the percentage error could be calculated, the AAS result, which was measured in mg/L needed to be converted to work out the concentration in grams per 300mls as the pieces of metal were dissolved in 300ml of aqua regia.

Tables 29a, 29b and 29c show the concentrations of the AAS samples at 168hours and the percentage errors of the AAS.

Table 30a – percentages errors for 23.3% aqua regia

| Element | Concentration (g/300ml) | % error |
|---|---|---|
| Nickel | 16.2611 | 23.39 |
| Cobalt | 22.8595 | 32.27 |
| Chromium | 6.3685 | 80.42 |
| Tungsten | 0.9748 | 3054.69 |
| Titanium | 0.0046 | - |
| Rhenium S.A | 1.4991 | 2812.85 |

Table 30b – percentage error for 14.15% aqua regia

| Element | Concentration (g/300ml) | % error |
|---|---|---|
| Nickel | 3.4630 | 63.12 |
| Cobalt | 3.0952 | 11.06 |
| Chromium | 0.0561 | 1977.77 |
| Tungsten | 3.5750 | 51711.59 |
| Rhenium | 23.1580 | 451.92 |
| Rhenium U.S | 17.1540 | 6650.89 |
| Titanium | 0.0065 | - |

Table 30c – percentage errors for 5% aqua regia

| Element | Concentration (g/300ml) | % error |
|---|---|---|
| Nickel | 0.6905 | 59.13 |
| Cobalt | 1.7780 | 31.41 |
| Chromium | 0.0577 | 2936.84 |
| Tungsten | 4.9925 | 184807.41 |
| Rhenium | 16.6520 | 15565.1 |
| Rhenium U.S | 21.1395 | 222.04 |
| Titanium | 0.0080 | - |

Nickel and cobalt seemed to have the most accurate AAS result for all three strengths of aqua regia, with the 23.3% aqua regia being the most accurate with only 23.39 and 32.37 percentage errors for nickel and cobalt respectively. The AAS result for tungsten was unbelievably inaccurate with the percentage error from the true value being from 3000% - 180000%. The percentage error for rhenium in the 14.15% aqua regia was much better than that of the 5% aqua regia with an error of just 451.92% compared to 15565.1%. The rhenium which used the ultra-sonic bath was opposite to this, with the 5% aqua regia having a percentage error of 222.04% and the 14.15% aqua regia had a percentage error of 6650.89%.

**3.3. Rhenium Molecular Imprinted Polymers results**

3.3.1. Molecular Imprinted Polymer Test 1 (188mg template)

3.3.1.1. Template removal and loading of analyte

All the samples mentioned in section 7.3 were diluted by a factor of four; therefore, to account for this, all results were multiplied by four to get the original concentration. Fig.29.1a shows the amount of rhenium present in the eluted samples at every stage of the removal and loading process. Fig.29.1b shows the quantity of rhenium present inside the MIP at every stage. Looking at Fig.29.1a it indicated that after the three initial rinses with water (A.R) and the elution of the template with 1M HCl the amount of rhenium detected on the AAS was in negative figures. After the third elution with 3M HCl rhenium started to be detected. There seemed to be a pattern where the amount of rhenium being eluted increased with each mole of HCl and then it would plateau off until a stronger concentration of HCl was used. After the 3M HCl had been used, 1172mg/L of rhenium had been eluted. Once the eight stages of 6M HCl were used, a further 3907.88mg/L of rhenium template had been removed. The amount of rhenium being eluted decreased to only 3475.32mg/L when the 8M HCl was used and the total amount of rhenium template removed before the analyte was added, was 8555.2mg/L. When the 3000mg/L (3g/L) ammonium perrhenate template was added to the MIP, 404mg/L was detected in the eluted solution. As the three wash stages (W1-3) were done, the amount of rhenium being detected decreased down to 319.04mg/L.

**Fig. 29.1a - AAS showing the quantity of rhenium eluted from MIP Test 1 (188mg)**

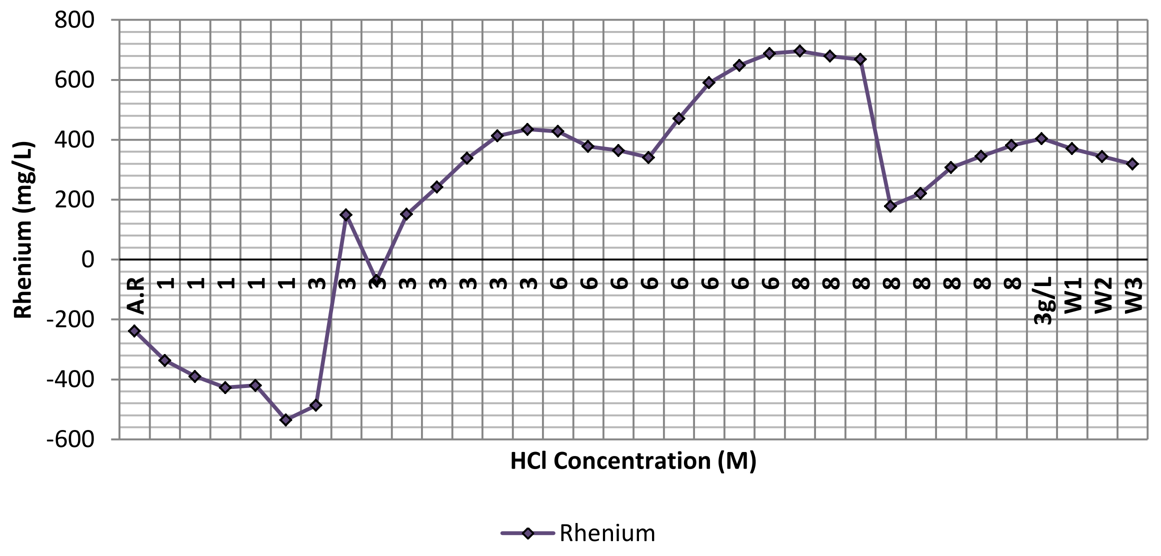
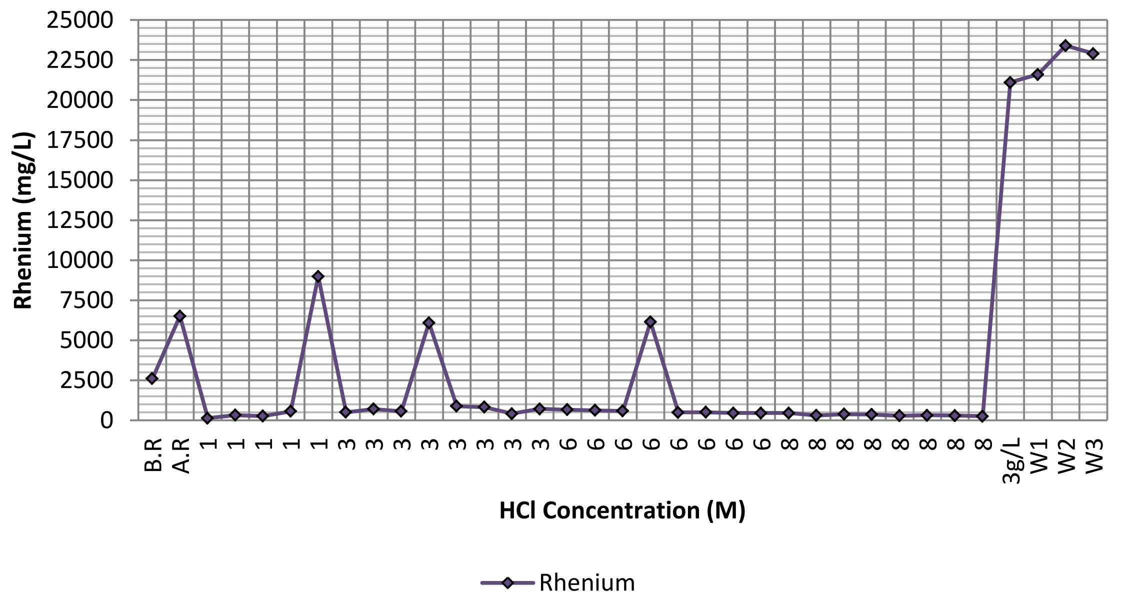



**Fig.29.1b - XRF showing the quantity of rhenium residue from the MIP Test 1 (188mg)**



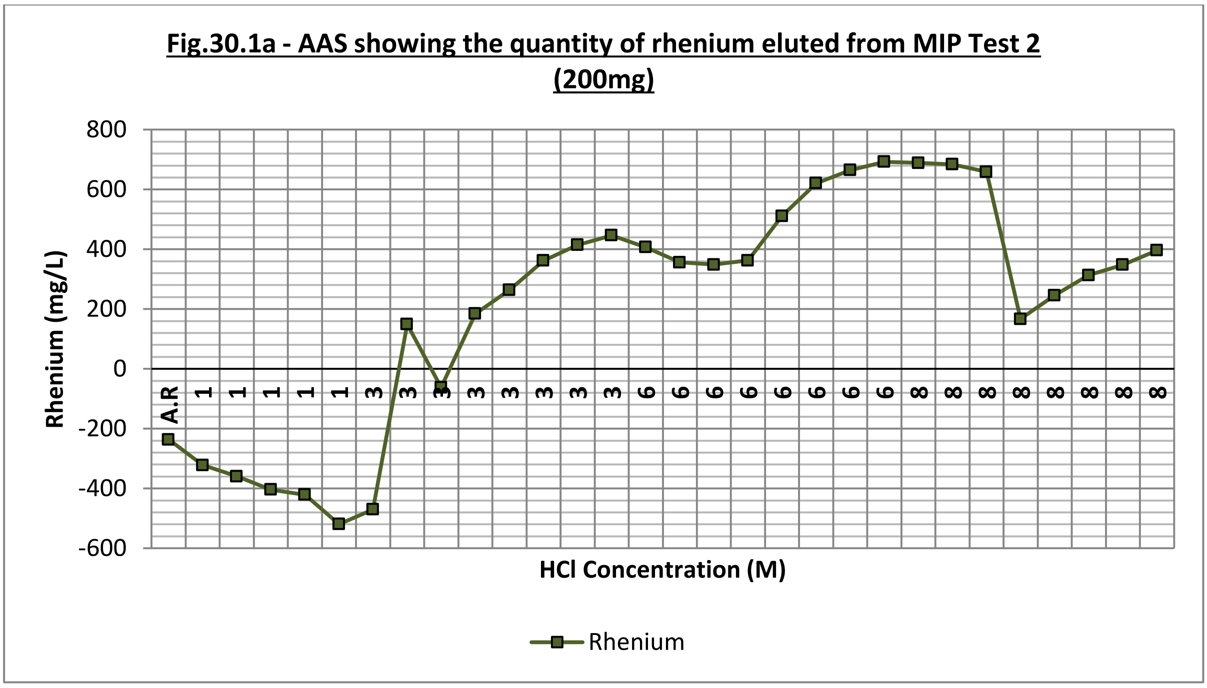

Looking at Fig.29.1b it shows that before the three initial washes with water (B.R) the amount of rhenium present was 2600mg/L, this increased to 6510mg/L after the three washes (A.R).

The amount of rhenium being detected in the MIP ranged from 130mg/L to 880mg/L during the removal of the template stage. There was however three anomalies that were detected at the 5th 1M HCl elution; the 4th 3M HCl elution and the 4th 6M HCl elution. The amount of rhenium being detected inside the MIP increased to 8990mg/L; 6090mg/L and 6150mg/L respectively. The reason for the anomalies is not clear; however factors such as dilution error or instrument error could have been a contributing factor. There was only 250mg/L of rhenium present in the MIP after the 8th 8M HCl elution, before the 3000mg/L ammonium perrhenate analyte was added. Once the 3000mg/L (3g/L) analyte was added, the amount of rhenium detected increased dramatically to 21100mg/L which is much higher than the 3000mg/L that was actually added. When the three washes with water were carried out, the amount of rhenium present increased slightly to 21600mg/L for wash 1 (W1); 23400mg/L for wash 2 (W2) and 22900mg/L for wash 3 (W3). This indicates that, even though the reported result is above the actual amount of analyte added to the MIP, the MIP was capable of holding the analyte and not allowing it to be eluted with the water.
To see the raw data and the calibration graph used for the AAS results go to appendix 12.

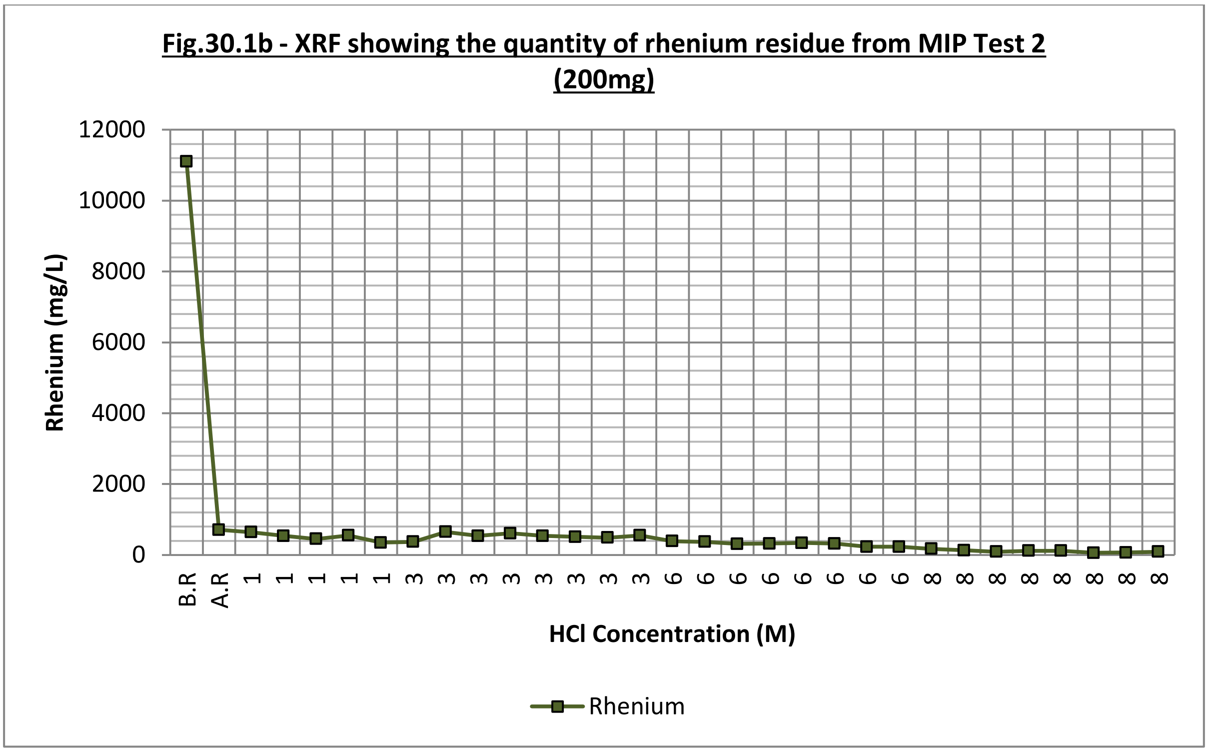
3.3.2. Molecular Imprinted Polymer Test 2 (200mg template)

3.3.2.1. Template removal

Looking at Fig.30.1a it shows the same pattern as MIP Test 1 where the amount of rhenium being eluted increased for the first few elutions with HCl and then it plateaus until a stronger concentration of HCl was used. The most amount of rhenium eluted using 3M HCl was 446.8mg/L with the maximum elution of 6M HCl being 692.4mg/L. When 8M HCl was used, the amount of rhenium being eluted was around the same as the 6M HCl (688.8 - 658.8mg/L) however this then dropped, with the maximum elution being 396.24mg/L.



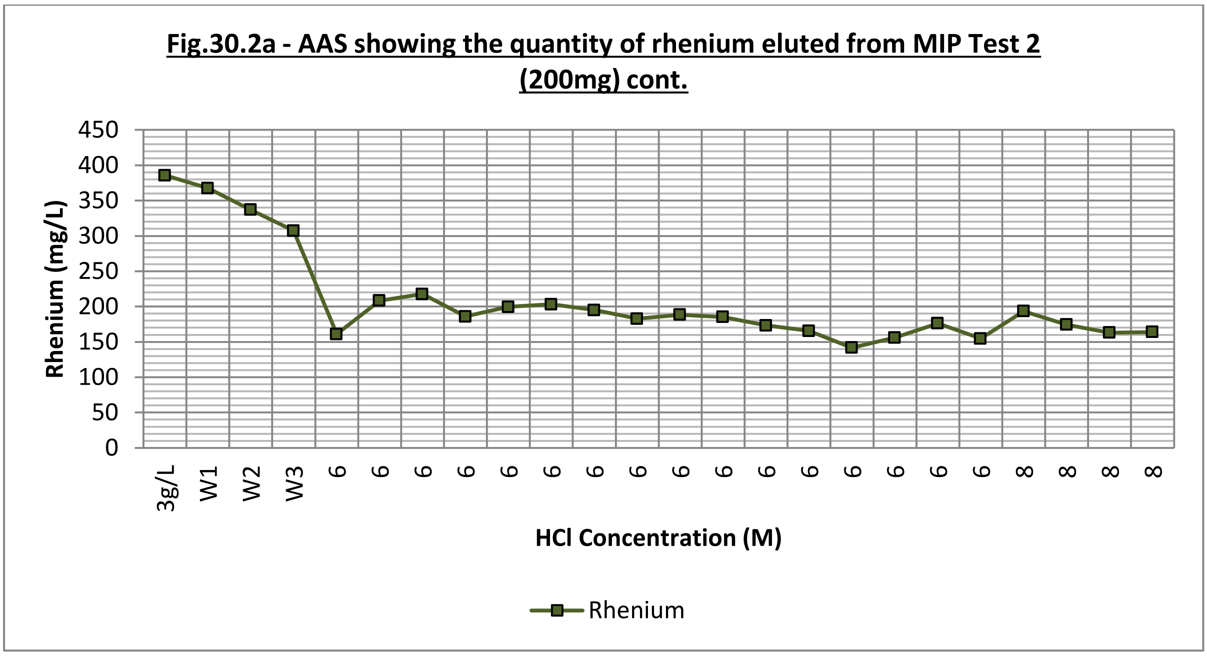

If Fig.30.1b is looked at, before any rinse was carried out on the MIP the amount of rhenium detected was 11100mg/L. This fell dramatically down to 710mg/L after the rinse (A.R), probably due to the removal of any template that had not bound to the MIP during the polymerisation process. After the first elution with 1M HCl, the amount of rhenium detected fell to 640mg/L and this kept on decreasing until only 90mg/L of rhenium was present once the 8M HCl elution steps had been carried out. The fact that the amount of rhenium detected in the MIP did not vary much during the template removal process, it would have been expected to have seen less variation in the AAS results.

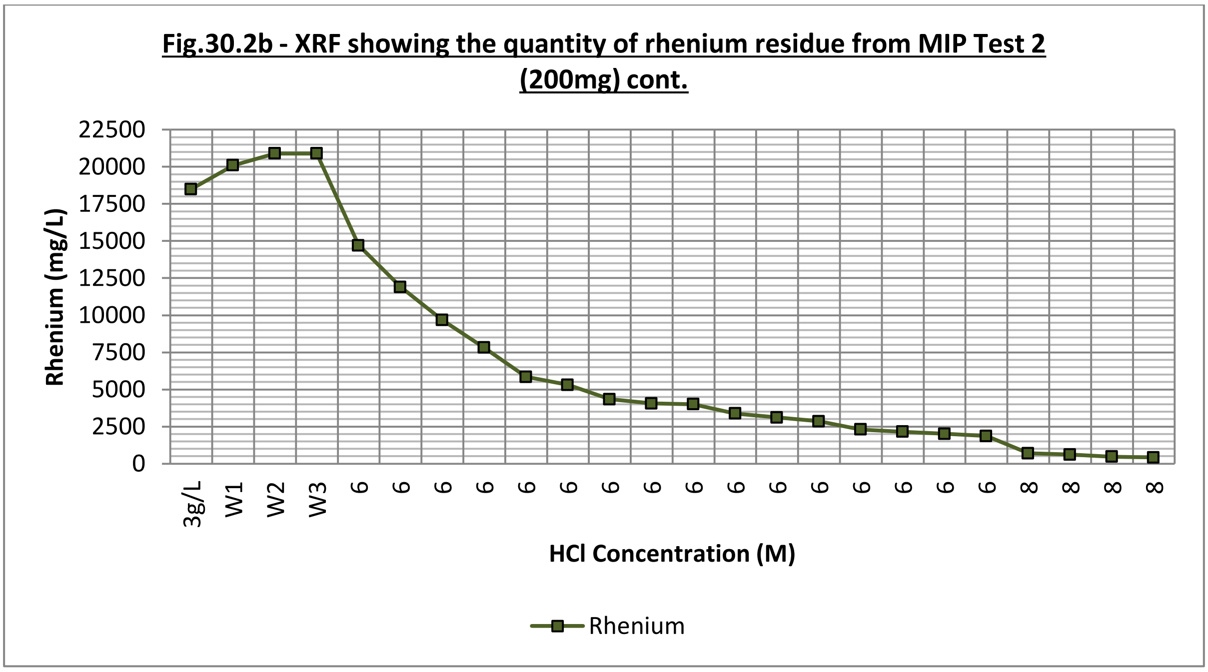



3.3.2.2. Analyte addition and removal

Looking at both Fig.30.2a and Fig.30.2b it showed that once the 3000mg/L of ammonium perrhenate had been added to the MIP, the amount of rhenium not being trapped in the MIP stayed roughly the same, with the AAS detecting 385.68mg/L of rhenium in the eluted solution. This had dropped slightly from the last 8M HCl elution (Fig.30.1a) where 396.24mg/L was detected before the analyte had been added. When the three washes had been carried out the amount of eluted rhenium fell slightly to 307.44mg/L which supports the XRF data in Fig.30.2b as the amount of rhenium detected inside the MIP increased from 18500mg/L when the analyte was added, to 20900mg/L after the third wash (W3). This shows that the water was not capable of removing any of the rhenium from the MIP, suggesting that a possible interaction between the MIP and analyte was taking place. Once the HCl was used to remove the analyte, the amount of rhenium being eluted from the MIP after each elution did not vary much with it ranging from 161mg/L - 217mg/L. The AAS results showed (Fig.30.2a) that only 3590.36mg/L of rhenium analyte was removed from the MIP whereas Fig.30.2b suggests that around 20000mg/L of rhenium had been removed as the XRF data in Fig.30.2b shows that the amount of rhenium detected in the

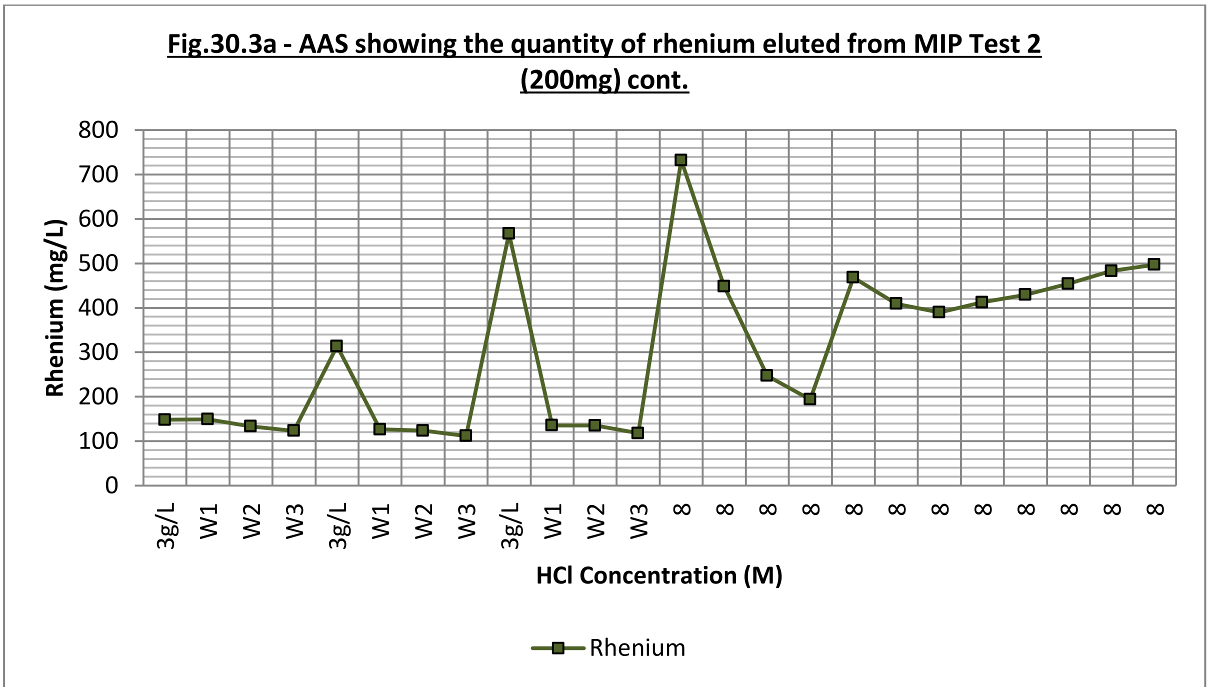
MIP fell from 20900mg/L after the third wash, down to 420mg/L after all the elution steps with HCl.




3.3.2.3. Maximum analyte loading and removal

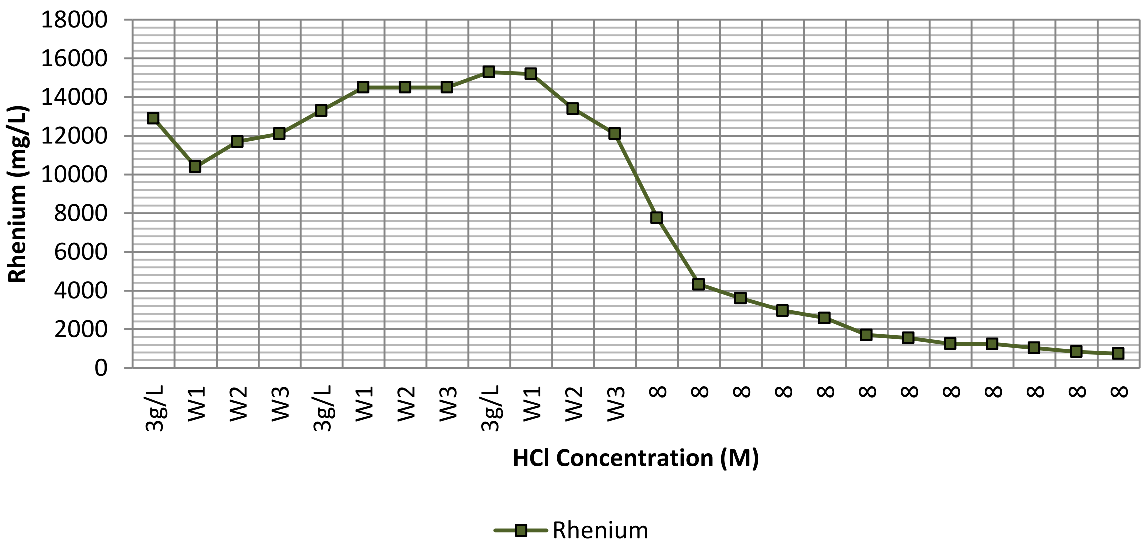
Looking at the AAS results in Fig.30.3a it shows that when the first 3000mg/L ammonium perrhenate analyte was added to the MIP, the amount of rhenium detected in the eluted solution fell to 148.16mg/L. When the second 3000mg/L analyte was added, the amount of rhenium detected increased slightly to 313.88mg/L. The amount of rhenium detected in the eluted solution increased again, up to 567.2mg/L, when the third 3000mg/L ammonium perrhenate analyte was added to the MIP. When the wash stages were carried out with water, the amount of rhenium being detected did not fluctuate much. When the 8M HCl was used to remove the trapped analyte, the amount of rhenium detected after the first elution increased from 117.96mg/L to 732.4mg/L. This dropped for the next three elutions down to 448.4mg/L; 247.24mg/L and 193.72mg/L respectively. On the fifth 8M HCl elution, the amount of rhenium detected increased to 468.4mg/L. This stayed roughly the same for the rest of the elutions.




The XRF data in Fig.30.3b showed that when the 3000mg/L analyte was added, the amount of rhenium detected inside the MIP increased from 420mg/L to 12900mg/L. This is 9480mg/L more than what the true value of 3420mg/L was. The XRF data also showed that as the second and third 3000mg/L analyte was added, the amount of rhenium detected in the MIP only increased slightly, to 13300mg/L for the second addition and 15300mg/L for the third. This means that when the second addition of rhenium analyte was added there should have been 2600mg/L of rhenium in the eluted sample. This however was not detected on the AAS as only 313.88mg/L of rhenium was detected in the eluted sample. When the third addition of the analyte was added, there should have been 1000mg/L of rhenium in the eluted sample according to the XRF data, however only 567.2mg/L was detected in the AAS. When the 8M HCl was used to remove the rhenium analyte from the

MIP, the amount of rhenium being detected inside the MIP by the XRF fell from 12100mg/L down to 7760mg/L for the first elution. This kept on falling until only 740mg/L of rhenium was detected in the MIP after all the elutions had been processed.

**Fig.30.3b - XRF showing the quantity of rhenium residue from MIP Test 2 (200mg) cont.**




The MIP was loaded again with three lots of 3000mg/L ammonium perrhenate analyte. Fig.30.4a shows that the amount of rhenium in the eluted sample when the first 3000mg/L analyte was added was 460.8mg/L. This increased slightly to 582mg/L when the second analyte was added and then the amount of rhenium in the eluted sample almost doubled to 1054.4mg/L when the third analyte was added. Again, when the water washes were carried out, the amount of eluted rhenium did not fluctuate much. When the first 8M HCl elution was carried out, the amount of eluted rhenium increased from 128.36mg/L to 761.6mg/L. This increased again to 858.8mg/L and then started to decrease down to 250mg/L of rhenium by the seventh run of the 8M HCl elution.

When looking at the XRF data (Fig.30.4b) it shows that the amount of rhenium being detected inside the MIP when the analyte had been added increased from 740mg/L to 10200mg/L which is an increase of 9460mg/L when there should only be an increase of 3000mg/L. When the second and third 3000mg/L ammonium perrhenate analyte was added, the amount of rhenium being detected only increased slightly to 11600mg/L and

13500mg/L respectively. The amount of rhenium detected inside the MIP decreased from 13600mg/L down to 2200mg/L after seven elutions with 8M HCl.

**Fig.30.4a - AAS showing the quantity of rhenium eluted from MIP Test 2 (200mg) cont.**

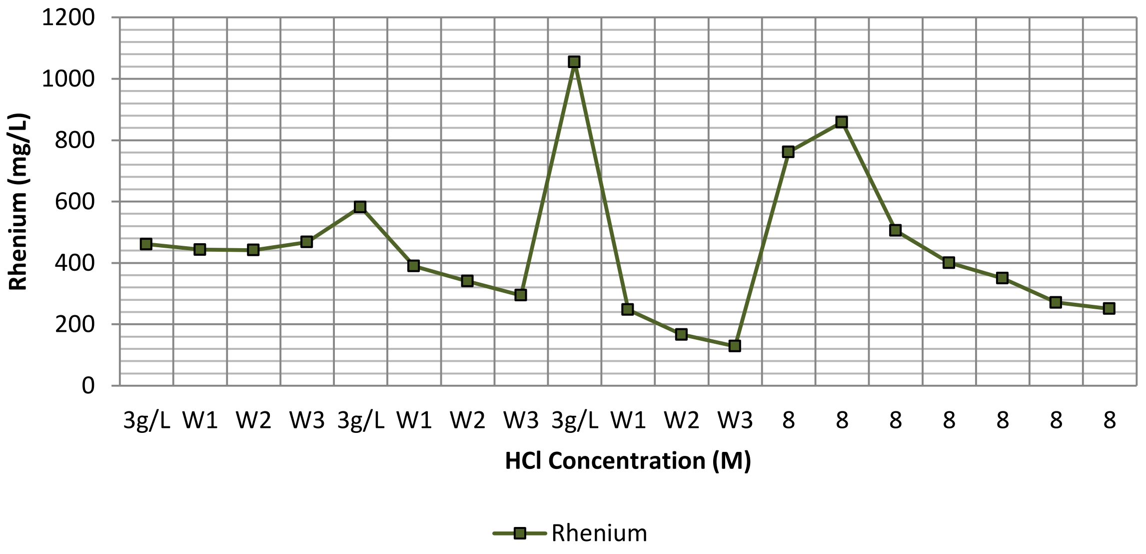
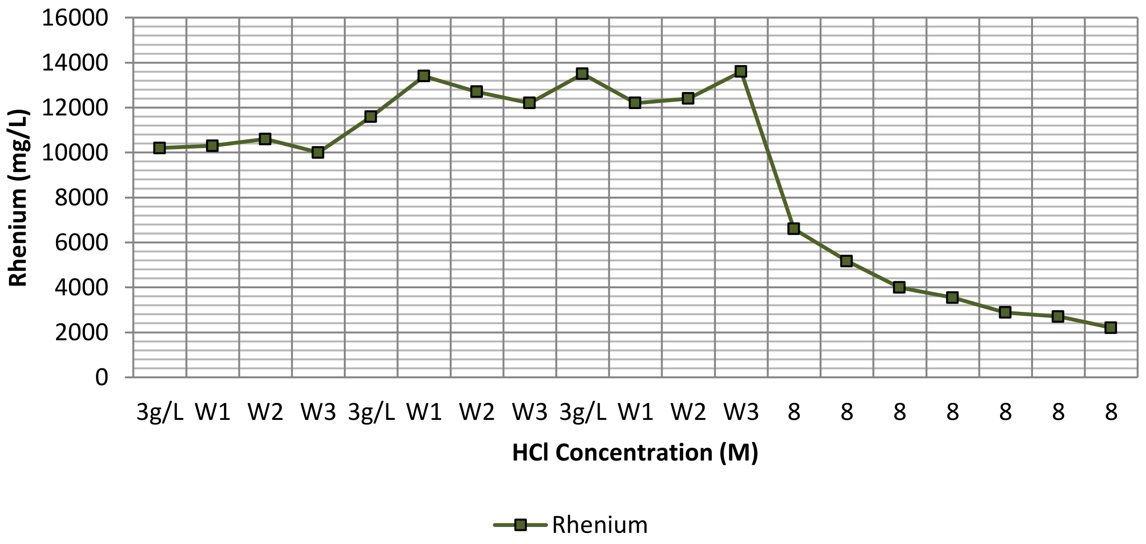


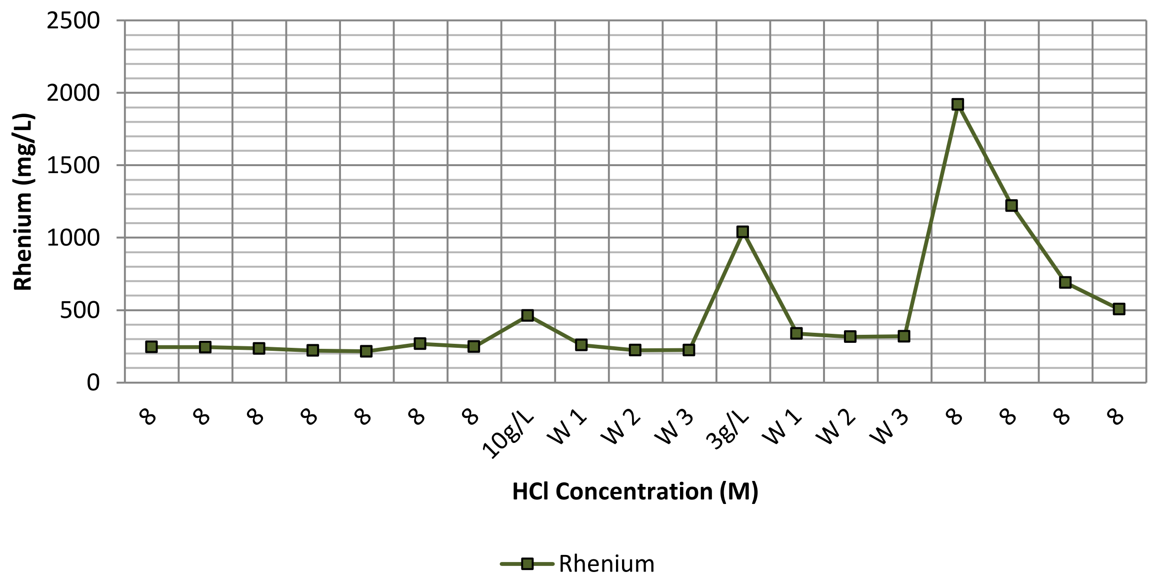

**Fig.30.4b - XRF showing the quantity of rhenium residue from MIP Test 2 (200mg) cont.**




3.3.2.4. Final Maximum analyte loading and removal

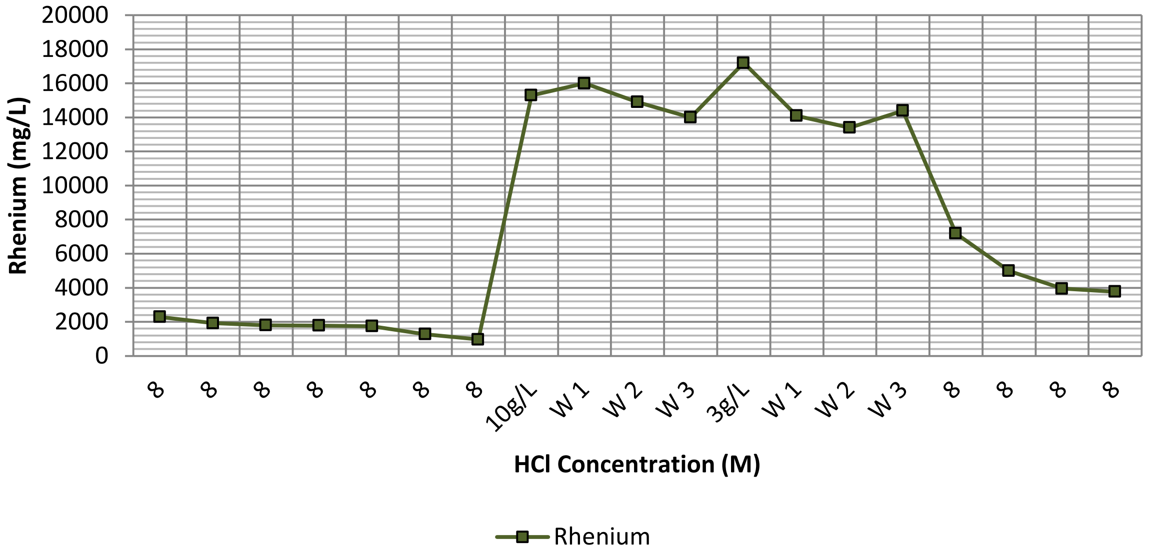
Looking at Fig.30.5a it shows that the amount of rhenium being detected in the eluted sample had levelled off during the last seven 8M HCl elution's with the results around 240mg/L for each elution. When the 10000mg/L of analyte was added, the amount of rhenium detected in the eluted sample only increased slightly from 247mg/L up to 462mg/L. When the 3000mg/L analyte was added, the amount of rhenium detected in the eluted sample increased to 1038.8mg/L. The amount of rhenium in the eluted sample increased to 1920mg/L after the first elution with 8M HCl. The second 8M HCl elution detected 1222mg/L of rhenium in the eluted sample. This then decreased to 689.6mg/L and 505.6mg/L for the last two 8M HCl elution's.

**Fig.30.5a - AAS showing the quantity of rhenium eluted from MIP Test 2 (200mg) cont.**




The XRF data (Fig.30.5b) shows that the amount of rhenium inside the MIP decreased from 2290mg/L to 960mg/L by the time all the HCl elution's had been carried out. When the 10000mg/L analyte had been added, the amount of rhenium detected increased to 15300mg/L which is 5300 more than what was added. When the 3000mg/L analyte was added the amount of rhenium detected increased to 17200mg/L. If all the analyte had been trapped the result should have been 18300mg/L. This supports the AAS result as 1038.8mg/L was detected in the eluted sample when the 3000mg/L was added and the XRF data suggests that only 1900mg/L of rhenium was trapped which means there was a loss of 1100mg/L. When the 8M HCl elution was carried out, the amount of rhenium detected inside the MIP decreased.

**Fig.30.5b - XRF showing the quantity of rhenium residue from MIP Test 2 (200mg) cont.**



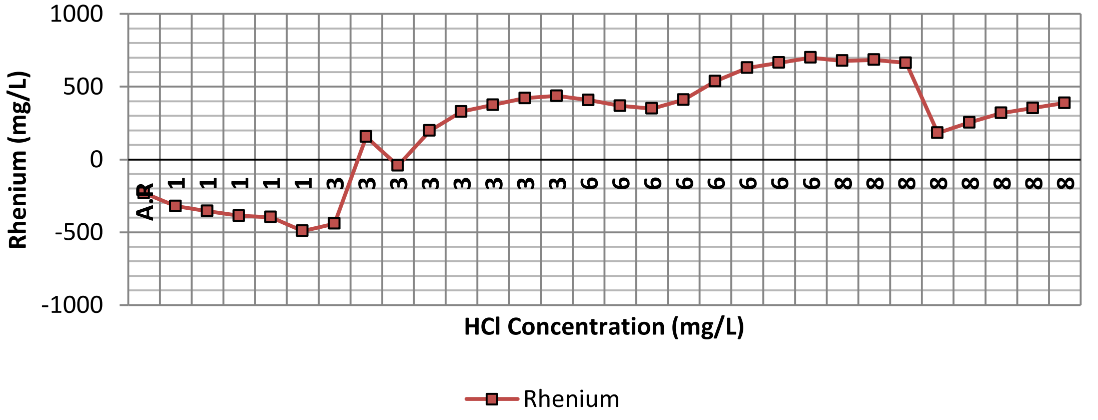

To see the XRF and AAS data, along with the raw data and calibration graph used, go to appendix 13.

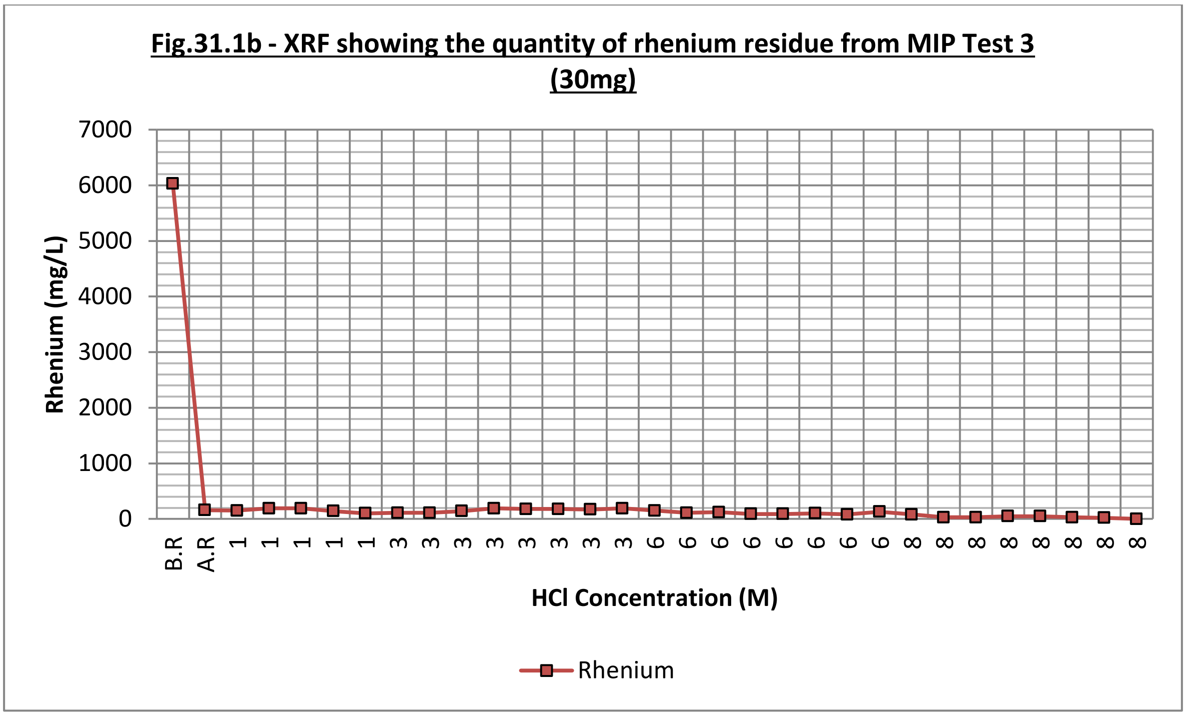
## 3.3.3. Molecular Imprinted Polymer Test 3 (30mg template)

### 3.3.3.1. Template removal

Just like MIP Test 1 and 2, Fig.31.1a shows that the same pattern is evident where the first few elutions showed an increase in the amount of rhenium being detected in the eluted solution and then it starts to plateau until a higher Molar concentration of HCl is used. The highest amount of rhenium eluted was when the 6M HCl was used, with an average of 508mg/L of rhenium being detected for each elution.

**Fig.31.1a - AAS showing the quantity of rhenium eluted from MIP Test 3 (30mg)**



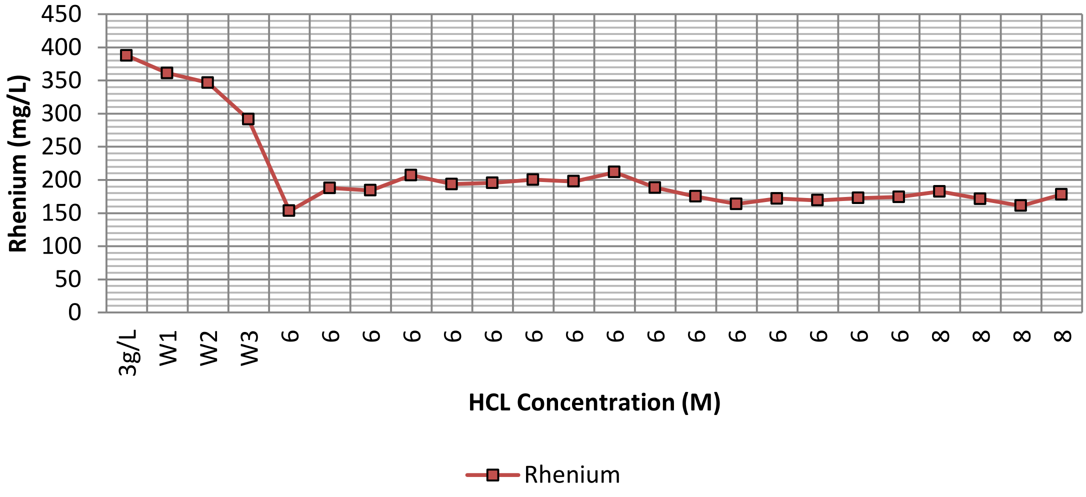



Looking at the XRF data (Fig.31.1b) it shows that before any rinse was carried out; the amount of rhenium detected inside the MIP was 6030mg/L. This dropped dramatically down to only 160mg/L after the rinse stages. There was a slow decrease in the amount of rhenium being detected inside the MIP while the HCl was being used to remove the template. The 8M HCl managed to remove all of the rhenium from the MIP by the eighth elution. Due to the low levels of rhenium being detected inside the MIP it would not be expected to have seen such fluctuation in the AAS data.

#### 3.3.3.2. Analyte addition and removal

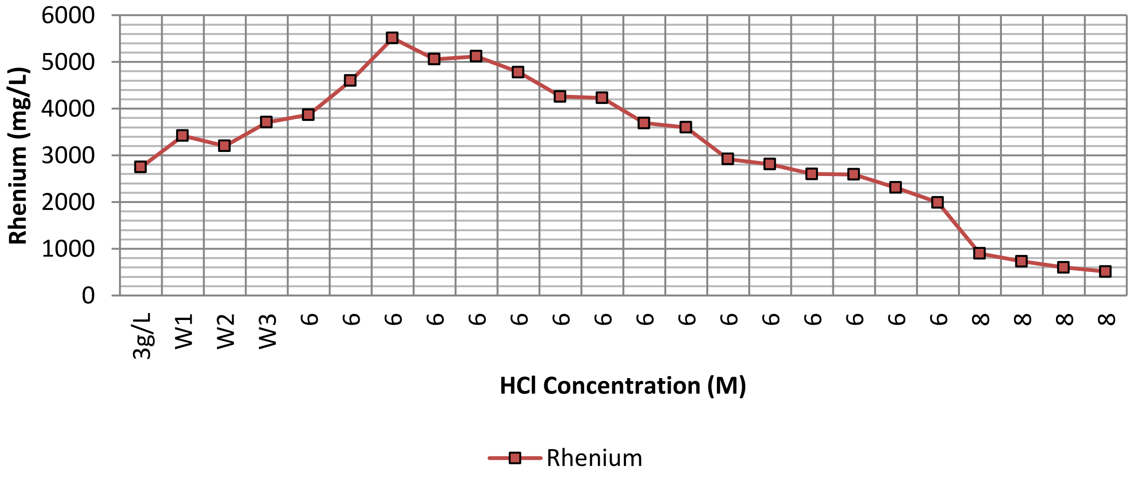
Looking at Fig.31.2a it shows that when the 3000mg/L analyte was added, the amount of rhenium detected in the eluted solution was 387.84mg/L. This decreased slightly when the three wash stages were carried out. The amount of rhenium being eluted when the HCl was used to remove the analyte did not fluctuate much, with on average 181.97mg/L of rhenium being detected for each elution.

Fig.31.2a - AAS showing the quantity of rhenium eluted from MIP Test 3 (30mg) cont.




The XRF data (Fig.31.2b) shows that when the first 3000mg/L analyte was added, the amount of rhenium detected inside the MIP increased to 2750mg/L. This meant that 250mg/L was eluted through which is less than the 387.84mg/L that was detected by the AAS. When the three washes were carried out, the amount of rhenium detected increased to 3710mg/L. This increase also occurred for the first three 6M HCl elutions, with the highest amount of rhenium being detected inside the MIP was 5510mg/L. The amount of rhenium being detected then started to decrease steadily, with only 510mg/L of rhenium inside the MIP after the fourth 8M HCl elution.

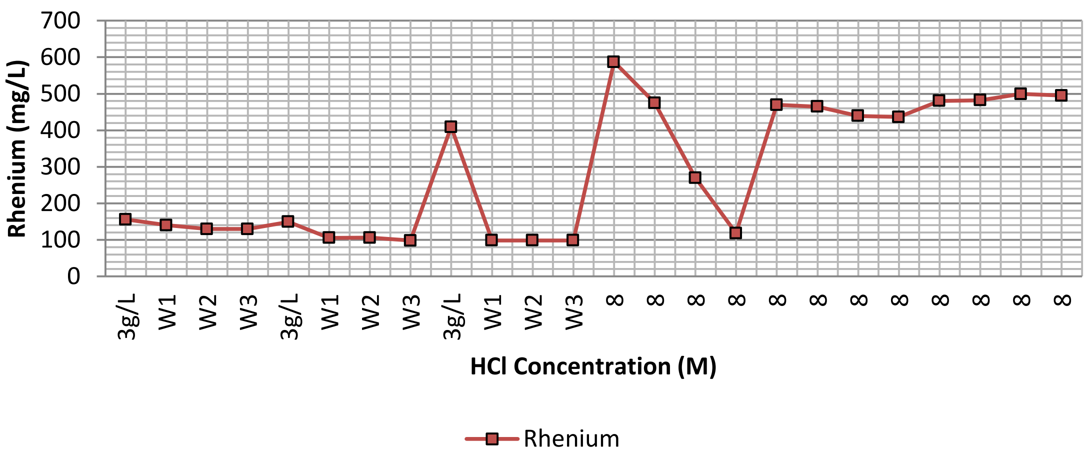
Fig.31.2b - XRF showing the quantity of rhenium residue from MIP Test 3 (30mg) cont.



### 3.3.3.3. Maximum analyte loading and removal

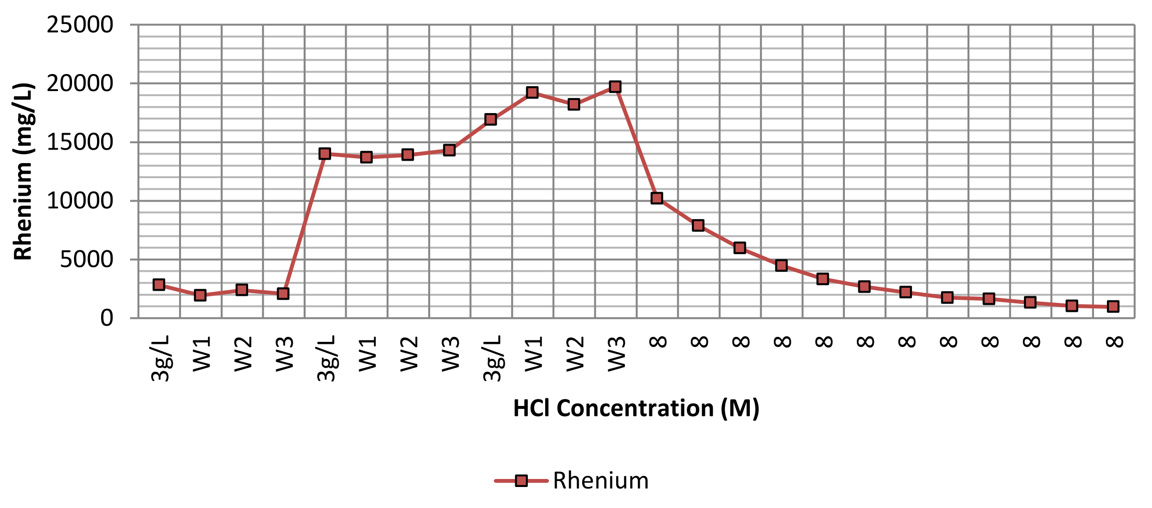
Fig.31.3a shows that when 3000mg/L analyte was added, the amount of rhenium detected was 156.04mg/L. This dropped slightly to 149.2mg/L when the second 3000mg/L analyte was added, but increased to 409.2mg/L when the third 3000mg/L analyte was added. 1719.16mg/L of rhenium was eluted from a total of 9000mg/L. When the first 8M HCl was used to remove the analyte, 587.2mg/L of rhenium was detected. The amount of eluted rhenium fell to only 118.2mg/L but then increased again to an average of 471mg/L for each elution.

Fig.31.3a - AAS showing the quantity of rhenium eluted from MIP Test 3 (30mg) cont.




Looking at the XRF data (Fig.31.3b) it shows that when the 3000mg/L analyte was added, the amount of rhenium detected inside the MIP increased from 510mg/L to 2810mg/L. This means 700mg/L of rhenium was not detected which is much higher than the 156.04mg/L that the AAS detected. When the second 3000mg/L analyte was added, the amount of rhenium detected increased dramatically to 14000mg/L which is much higher than what would be expected as only a total of 6000mg/L had been added. The amount of rhenium detected inside the MIP increased again, to 16900mg/L when the third analyte had been added. When the 8M HCl was used to remove the analyte, there was a sharp decrease in the amount of rhenium detected inside the MIP but this eventually started to plateau.

**Fig.31.3b - XRF showing the quantity of rhenium residue from MIP Test 3 (30mg) cont.**




The MIP was loaded again and Fig.31.4a shows that when the first 3000mg/L analyte was added, the amount of rhenium detected in the eluted solution was 480mg/L. This decreased to 410.8mg/L when the second analyte was added, but when the third analyte was added, the amount of rhenium detected increased to 652.4mg/L. A total of 4233.04mg/L of rhenium was eluted which is just under half of 9000mg/L that was added to the MIP. When the 8M HCl was used to remove the analyte, 918mg/L was eluted with the first 8M HCl. This increased to 1221.6mg/L for the second and then decreased to 731.6mg/L for the third. By the seventh 8M HCl elution, 4527.76mg/L of rhenium had already been eluted.

**Fig.31.4a - AAS showing the quantity of rhenium eluted from MIP Test 3 (30mg) cont.**

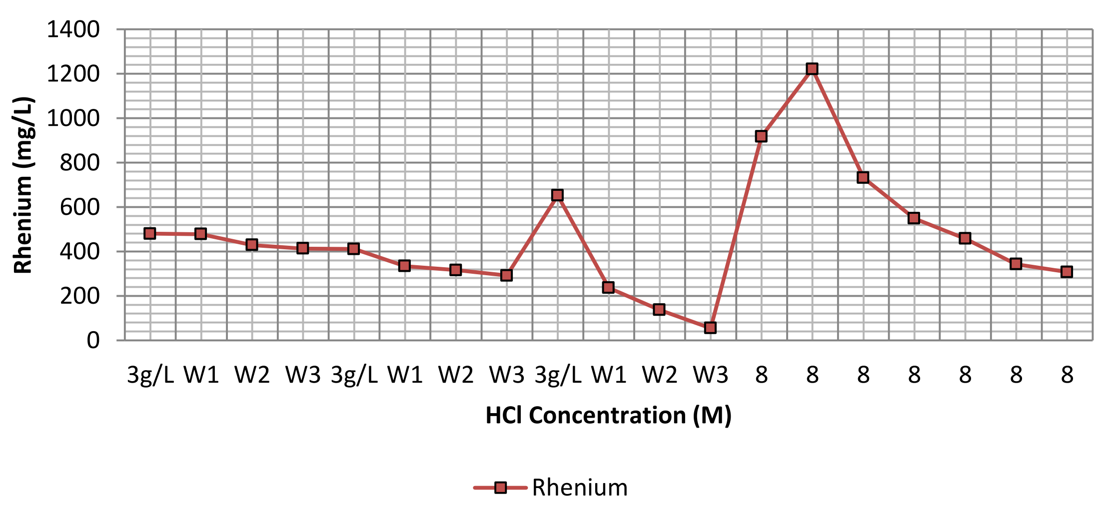
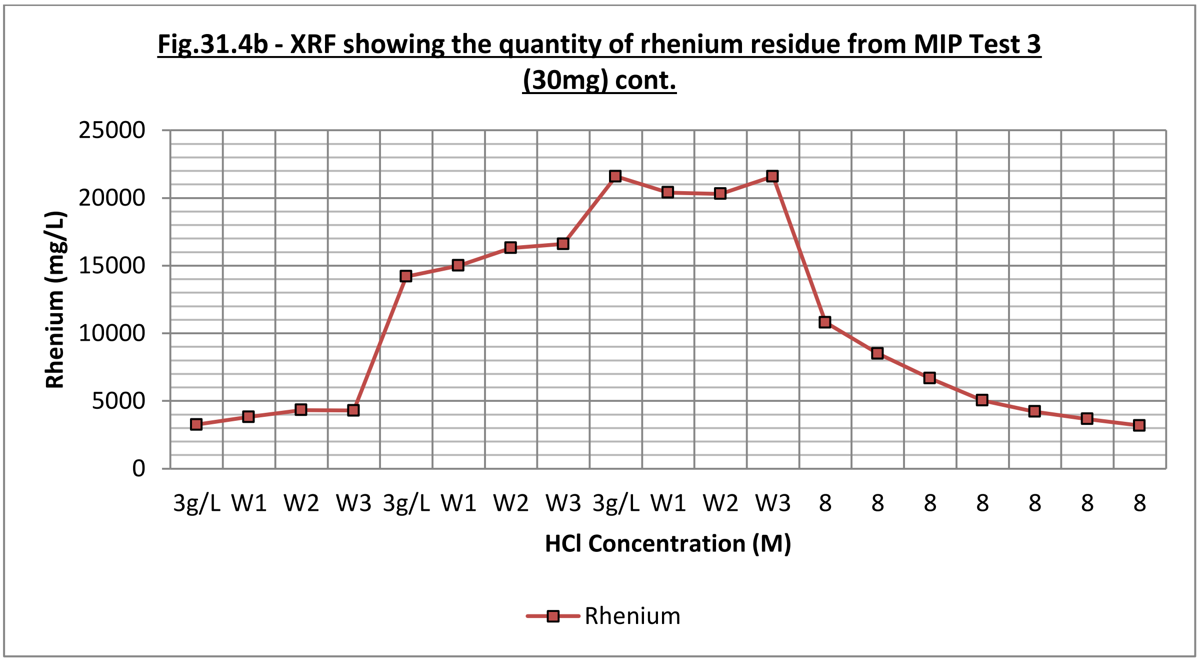
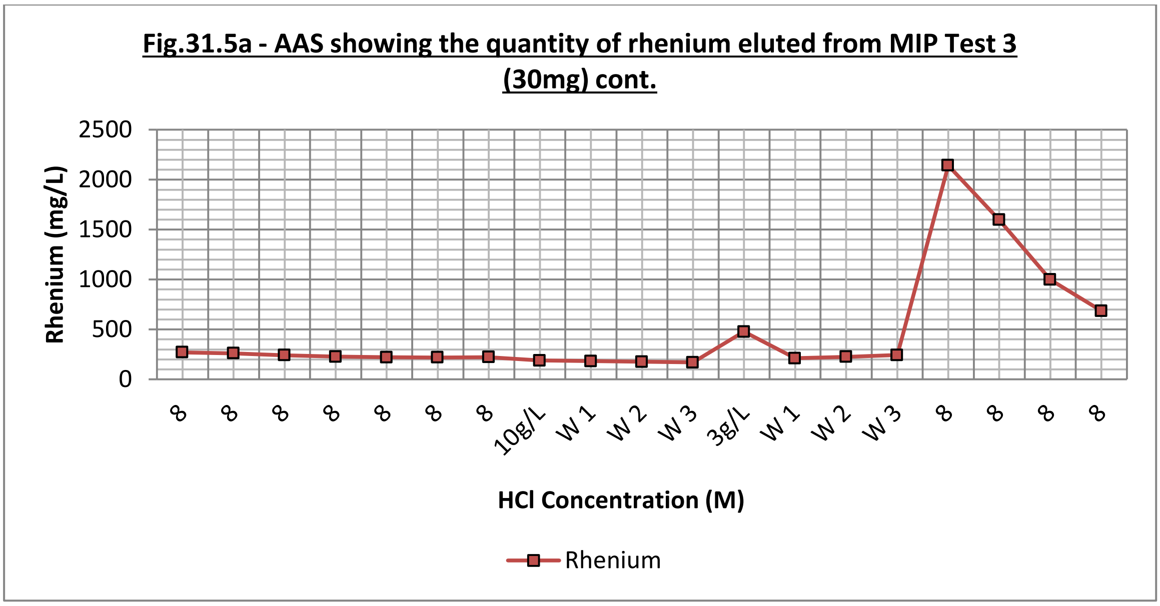


Fig.31.4b shows that when the first 3000mg/L analyte was added, the amount of rhenium inside the MIP increased from 960mg/L to 3250mg/L, which is a total of 2290mg/L that was detected. This means that 710mg/L was not captured, however only 480mg/L of rhenium was detected in the eluted sample. Again, when the second 3000mg/L analyte was added, the amount of rhenium detected increased dramatically to 14200mg/L. This increased further to 21600mg/L when the third analyte had been added. When the 8M HCl was used to remove the analyte, there was a sharp decrease of rhenium detected in the MIP, from 21600mg/L after the third wash, down to 10800mg/L after the first 8M HCl elution. After this point, there was a steady decrease in the amount of rhenium detected.

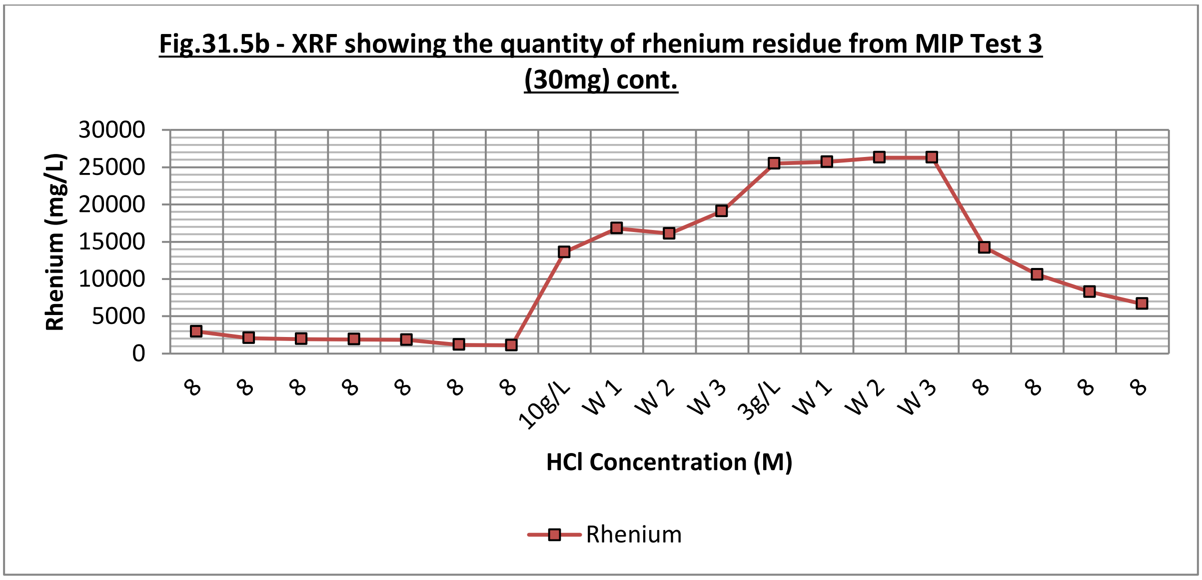



3.3.3.4. Final Maximum analyte loading and removal

Fig.31.5a shows that even when 10000mg/L of analyte is added to the MIP at once, only 189.32mg/L of rhenium was detected in the eluted solution. This only increased slightly to 477.6mg/L when a further 3000mg/L of analyte was added. When the first 8M HCl was used to remove the analyte, the first elution detected 2142.8mg/L of rhenium. This fell to 1598.4mg/L; 998.4mg/L and 686mg/L for the second, third and fourth, 8M HCl elution.




The XRF data (Fig.31.5b) shows that when the 10000mg/L analyte was added, the amount of rhenium detected increased from 1100mg/L to 13600mg/L which is 2500mg/L higher than the 10000mg/L that was added. When the three washes were carried out, there was not much change in the amount of rhenium detected. When the 3000mg/L analyte was added, the amount of rhenium detected increased from 19100mg/L to 25500mg/L. When the 8M HCl was used to remove the analyte, there was a sharp drop in the amount of rhenium detected, from 26300mg/L down to 14200mg/L. There was then a steady decrease in the amount of rhenium detected.

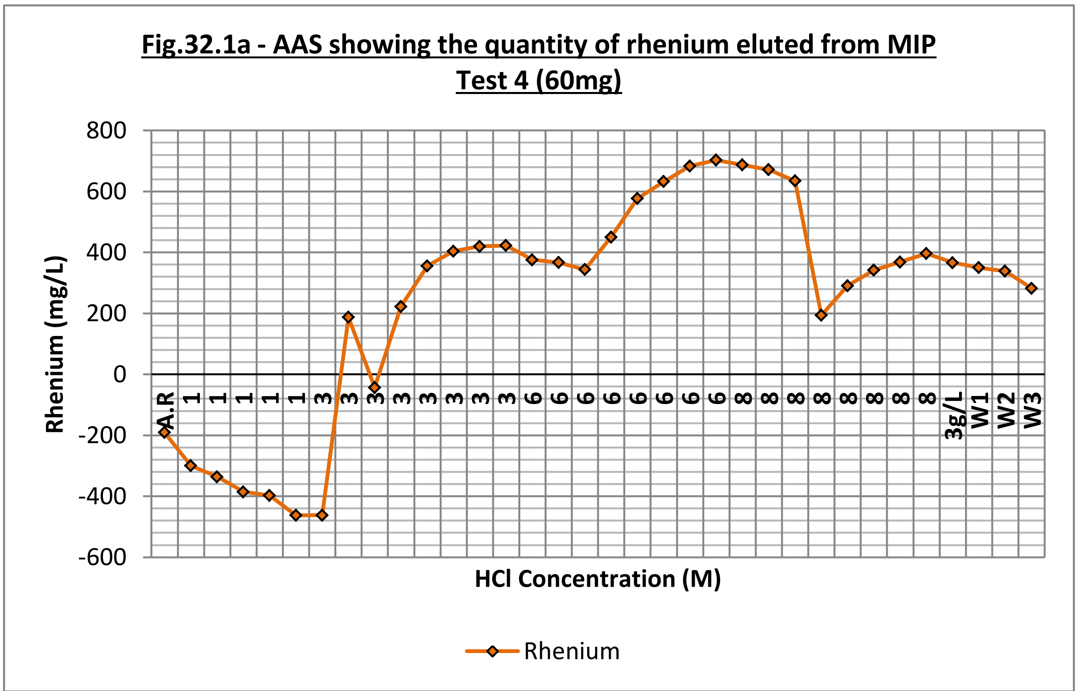



To see the XRF and AAS raw data as well as the calibration graph used for the AAS, go to appendix 14.

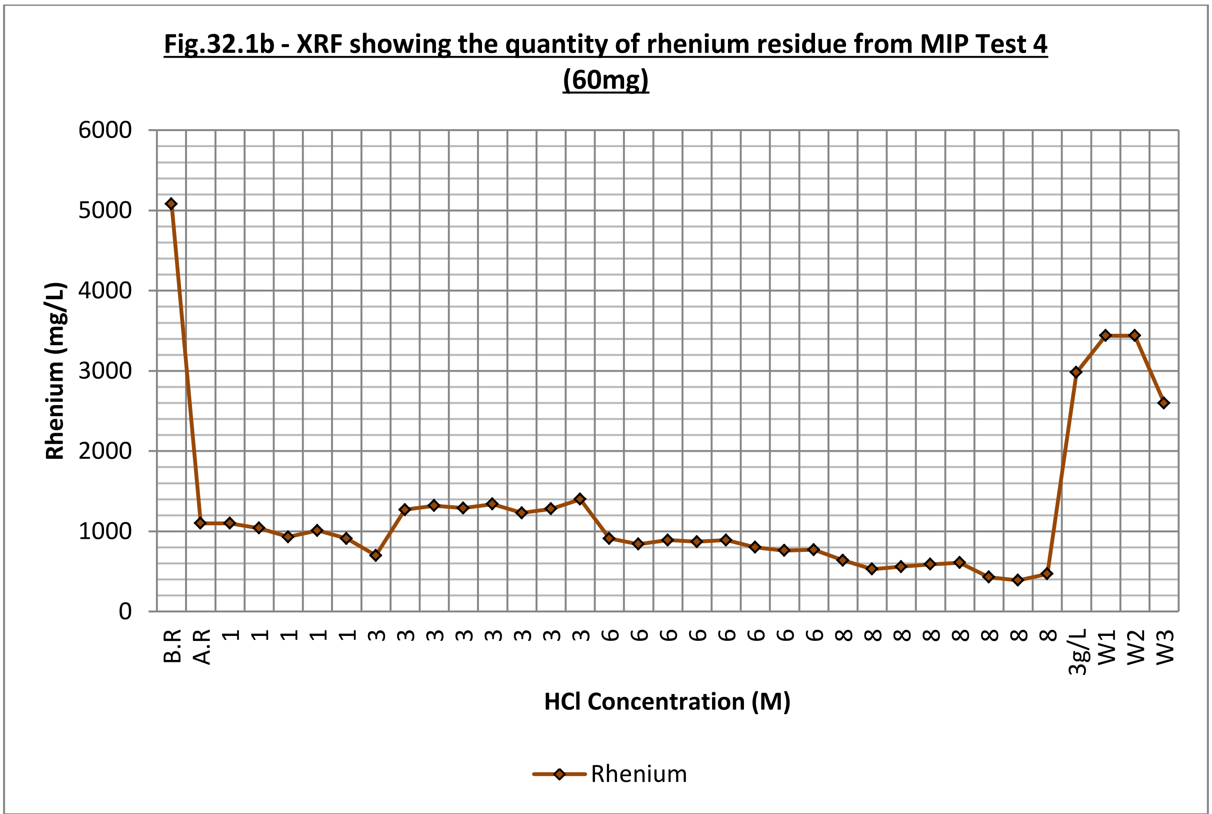
3.3.4. Molecular Imprinted Polymer Test 4 (60mg template)

3.3.4.1. Template removal and analyte addition

Looking at Fig.32.1a it shows that the amount of rhenium being detected in the eluted solution when 1M HCl was used produced negative results. When the 3M HCl was used rhenium was finally detected in the eluted solution. The amount being detected increased for the first few elutions but then started to plateau. The same pattern was observed when the 6M HCl was used as well. When the 8M HCl was used to remove the template, the first three elutions were on average 664.53mg/L. This dropped considerably down to 193.88mg/L on the fourth elution and then slowly increased up to 396.56mg/L by the eighth elution. When the 3000mg/L analyte was added to the MIP, the amount of rhenium being eluted in the solution was 366.36mg/L. The amount being detected decreased when the three wash stages were carried out.




Looking at the XRF data (Fig.32.1b) it shows that before any rinse stage was carried out with the MIP, there was 5080mg/L of rhenium detected. This dropped to 1100mg/L after the rinse stage. The data shows that when the 1M HCl was used to remove the template, there was not much of a decrease in the amount of rhenium detected in the MIP. Surprisingly, when the 3M HCl was used, the amount of rhenium detected actually increased from around 1000mg/L to 1300mg/L, suggesting that the 3M HCl was not strong enough to break any interactions between the MIP and rhenium. The 6M HCl and 8M HCl showed a steady decrease in the amount of rhenium detected inside the MIP. When the first elution with 6M HCl was carried out, 910mg/L was detected inside the MIP. This decreased to 470mg/L by the time the eighth 8M HCl elution had taken place. When the 3000mg/L analyte was added, the amount of rhenium detected inside the MIP increased to 2980mg/L which meant that 490mg/L of rhenium was eluted through. This was close to the 366.36mg/L of rhenium that was detected in the eluted solution on the AAS (Fig.32.1a).




3.3.4.2. Analyte removal and maximum loading and removal

Fig.32.2a shows that there was a steady decrease in the amount of rhenium being detected in the eluted solution when the 8M HCl was used to remove the analyte. When the first 3000mg/L analyte was added, only 98.32mg/L of rhenium was detected in the eluted solution. This increased to 149mg/L when the second 3000mg/L analyte was added. When the third, fourth and fifth analyte was added, the amount of rhenium detected in the eluted solution increased to 366.48mg/L; 753.2mg/L and 1142.4mg/L respectively. When the sixth analyte was added, the amount of rhenium detected fell to 809.6mg/L. A total of

18000mg/L of analyte had been added to the MIP and the AAS data shows that 5593.16mg/L of rhenium had not been captured in the MIP, indicating that the maximum loading capacity of the MIP test 4 was around 12500mg/L. When the 8M HCl was used to remove the analyte, a total of 3980.04mg/L of rhenium was removed from the MIP and detected on the AAS.

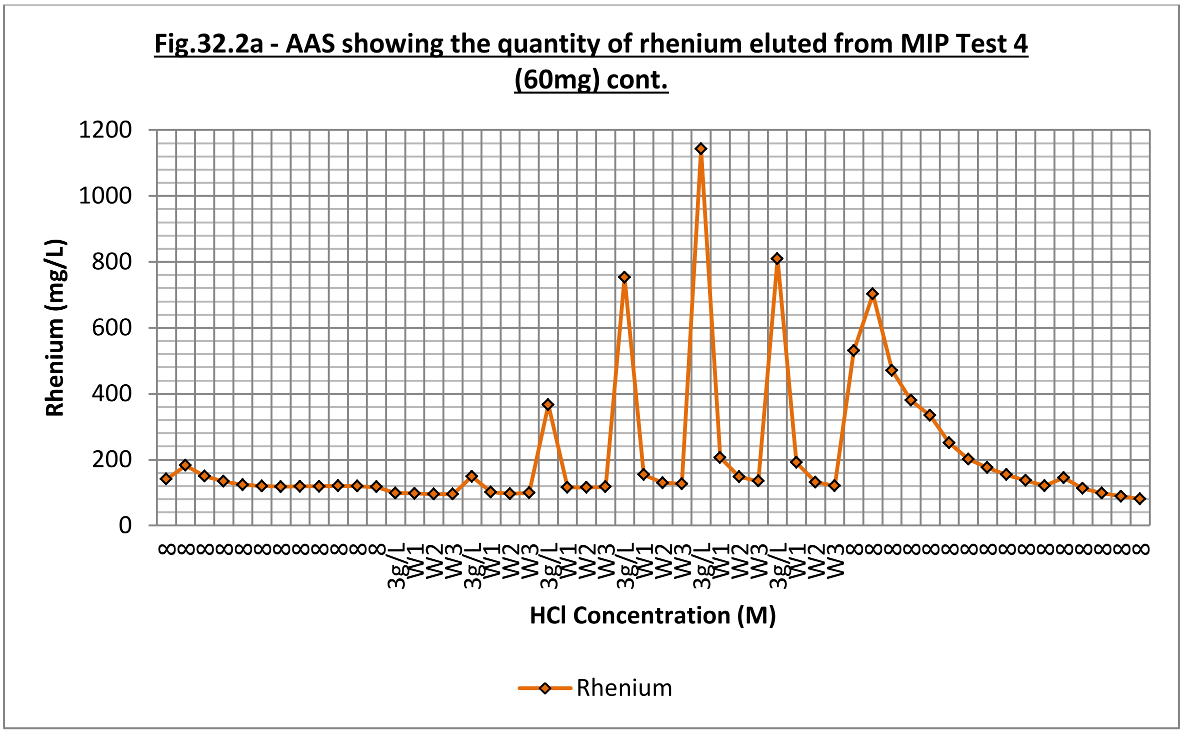



Fig.32.2b shows that there was a steady decrease in the amount of rhenium detected inside the MIP as the 8M HCl was used to remove the analyte with only 750mg/L of rhenium detected once all twelve elutions had taken place. When the 3000mg/L analyte was added, the amount of rhenium detected increased to 3380mg/L, which meant that only 2630mg/L was captured with 370mg/L being eluted. This is higher than the 98.32mg/L of rhenium which was detected on the AAS. The second 3000mg/L analyte detected 6460mg/L rhenium inside the MIP, which was an increase of 2700mg/L. The third, fourth and fifth addition of the analyte increased the amount of rhenium detected inside the MIP to 9390mg/L; 12600mg/L and 15000mg/L respectively. The three wash stages between each analyte addition increased the amount of rhenium detected which means that the total amount of rhenium captured for the third, fourth, and fifth stage was 2410mg/L; 2650mg/L and 1700mg/L respectively. This supports the AAS data (Fig.32.2a) which showed that as the more analyte was added, the more rhenium was detected in the eluted solution. The sixth

analyte addition increased the amount of rhenium detected inside the MIP to 15700mg/L which suggests only 900mg/L of rhenium was captured. Out of the 18000mg/L total analyte passed through the MIP, the results show that just over 12000mg/L was captured. When the 8M HCl was used to remove the analyte, the amount of rhenium detected inside the MIP decreased steadily.

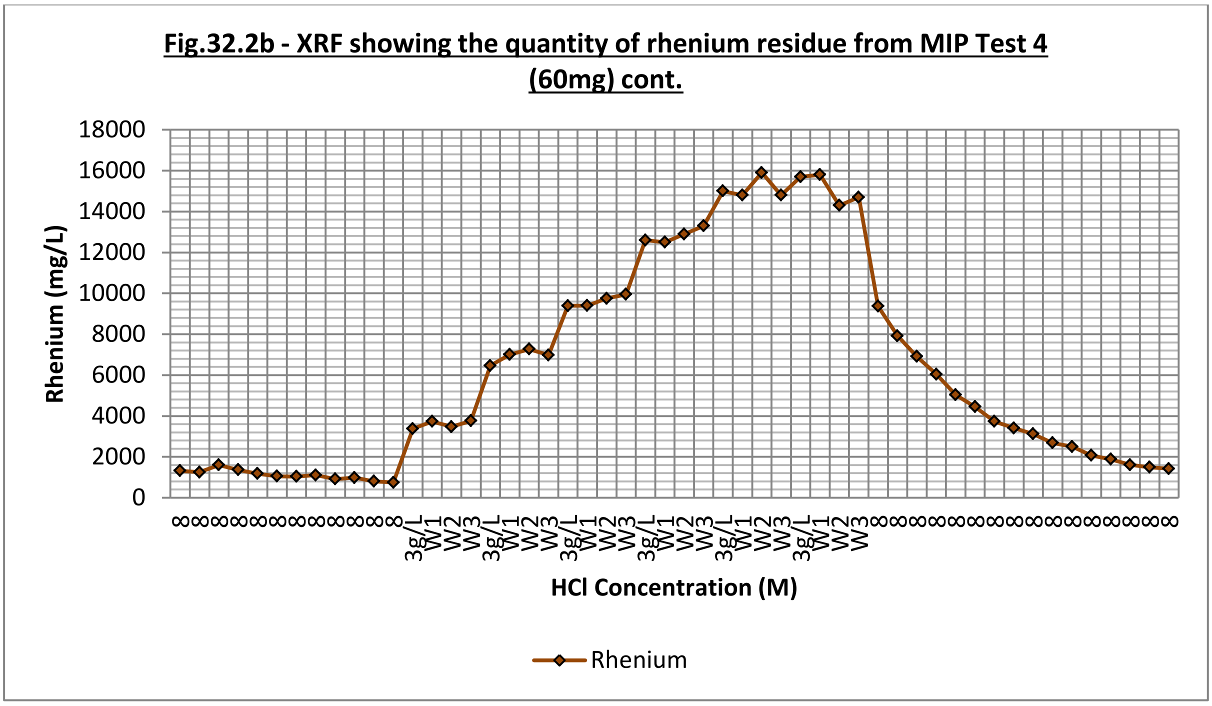


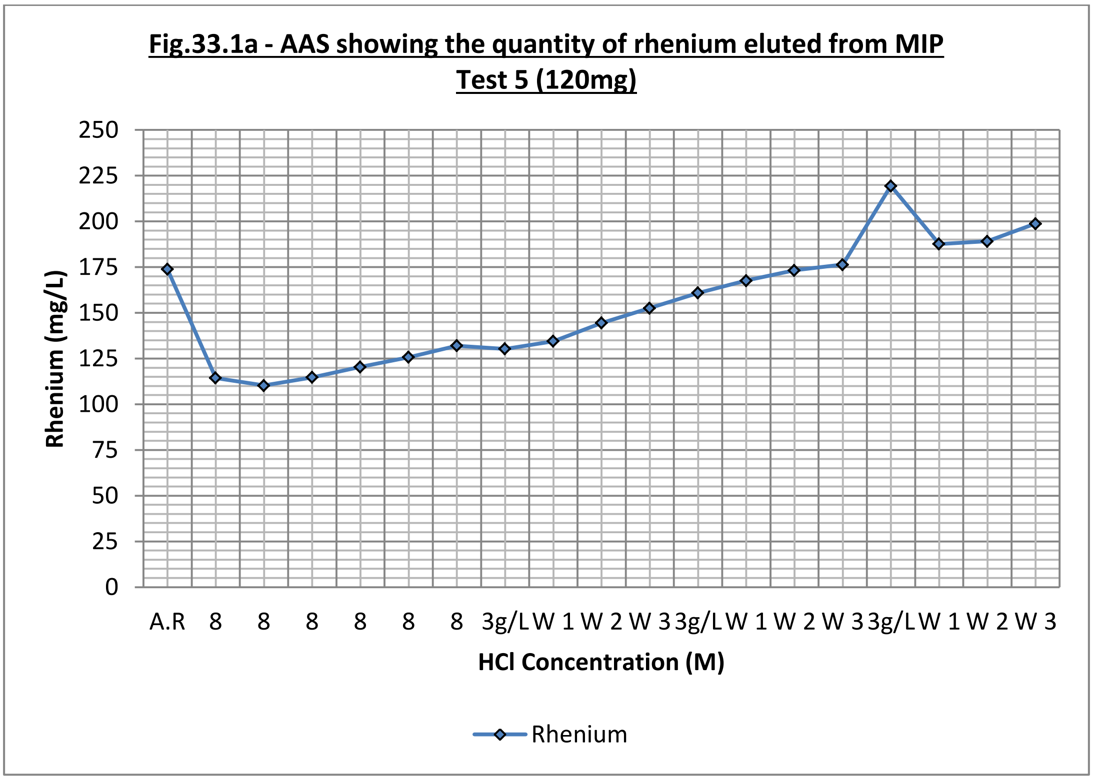
**Fig.32.2b - XRF showing the quantity of rhenium residue from MIP Test 4 (60mg) cont.**

To see the XRF and AAS raw data and calibration graph used for the AAS results, go to appendix 15.

### 3.3.5. Molecular Imprinted Polymer Test 5 (120mg template)

#### 3.3.5.1. Template removal and maximum loading of analyte

Looking at Fig.33.1a it shows that when the 8M HCl was used to remove the template the amount of rhenium eluted into the solution was around 114mg/L with this increasing to 132mg/L by the sixth elution. This is slightly more than what the XRF data suggests was removed. The XRF data (Fig.33.1b) shows that for each 8M HCl elution and average of 62mg/L of rhenium was being removed from inside the MIP. Looking at the AAS data (Fig.33.1a) when the first 3000mg/L analyte was added to the MIP the amount of rhenium detected in eluted solution was 130.28mg/L. This increased steadily as the washes were carried out and the second 3000mg/L analyte and wash stages were completed. When the third 3000mg/L analyte was added there was a noticeable increase in the amount of rhenium detected in the eluted solution. The amount of rhenium increased from 176.4mg/L to 219.44mg/L. This suggests that the MIP is reaching its maximum loading capacity and so not all of rhenium was being trapped by the MIP.




Looking at Fig.33.1b it shows that when the first 3000mg/L ammonium perrhenate analyte was added the amount of rhenium detected inside the MIP increased from 570mg/L up to 10950mg/L. This is much higher than the 3000mg/L which would be expected to be observed. Despite the high quantity of rhenium being detected, the amount of rhenium increased by roughly 3000mg/L when the second and third 3000mg/L analyte was added to 13200mg/L and 16600mg/L respectively.

**Fig.33.1b - XRF showing the quantity of rhenium residue from MIP Test 5 (120mg)**

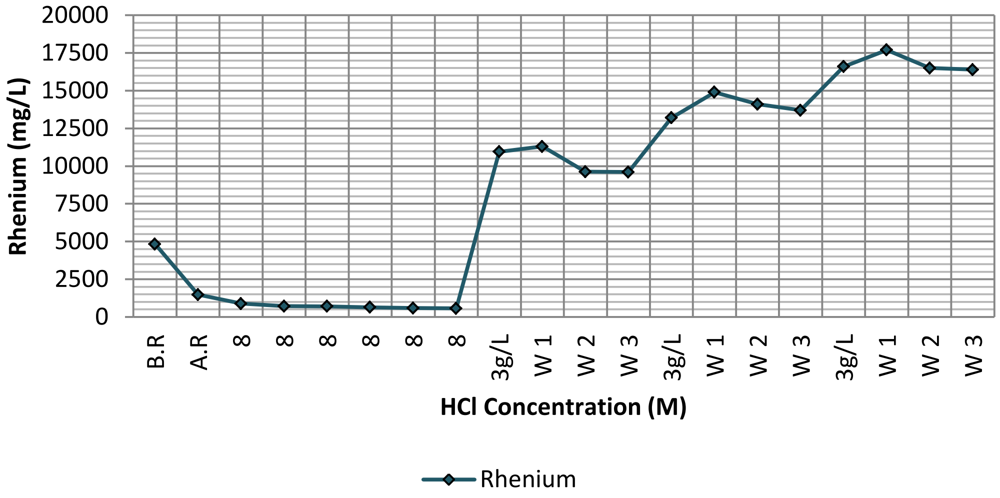
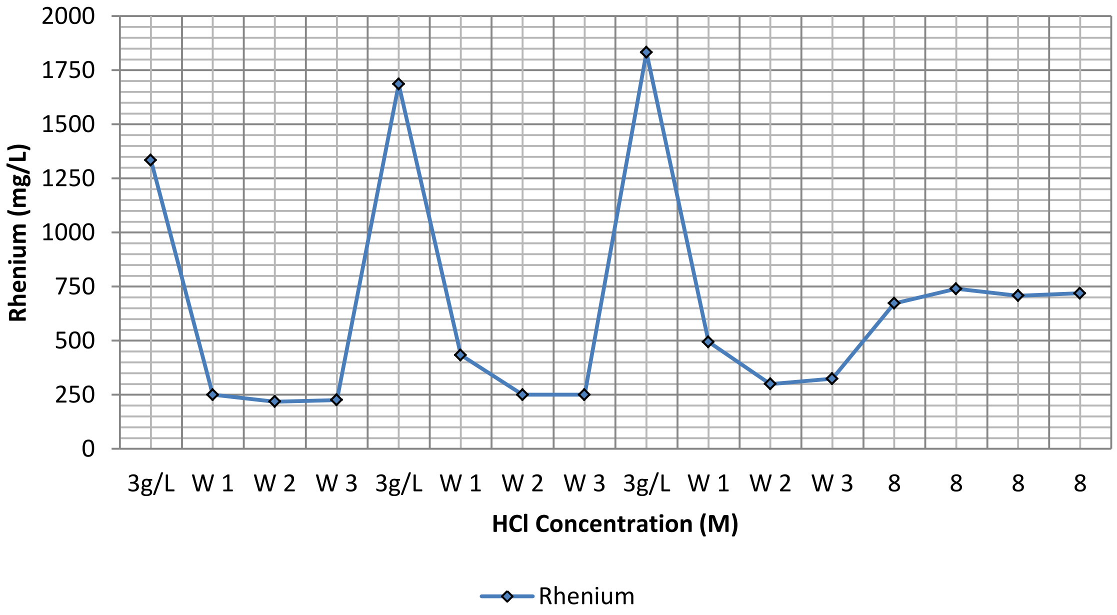


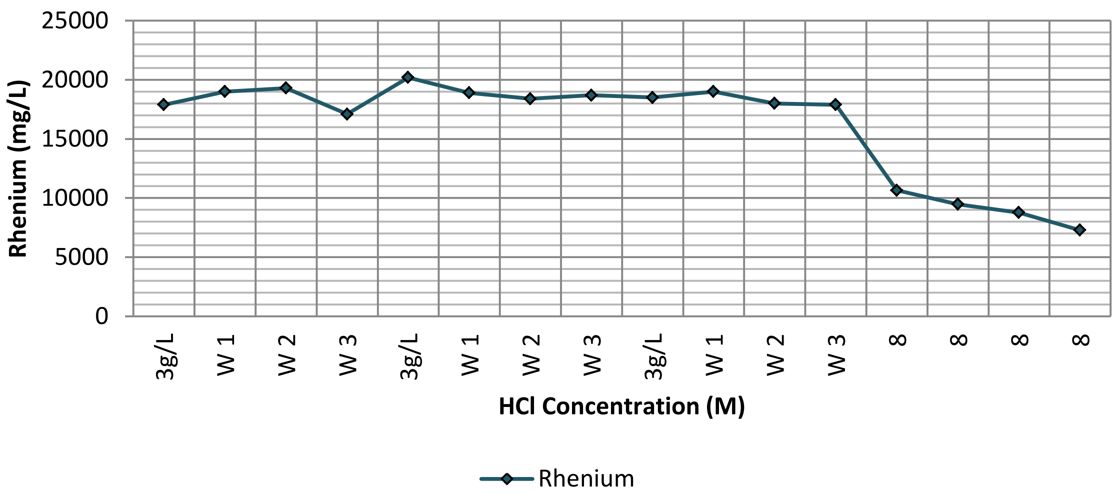

Fig.33.2a shows that when the fourth, fifth and sixth 3000mg/L analyte was added to the MIP, the amount of rhenium detected in the eluted solution increased dramatically. The amount being detected increased from 219.44mg/L when the third analyte was added, up to 1334.8mg/L; 1685.6mg/L and 1832.8mg/L when the fourth, fifth and sixth 3000mg/L analyte was added. This suggests that the MIP had reached it maximum loading and could not hold any more rhenium.

**Fig.33.2a - AAS showing the quantity of rhenium eluted from MIP 5 (120mg) cont.**



The XRF data (Fig.33.2b) supports the AAS data, as when the fourth 3000mg/L analyte was added, there was only an increase of 1300mg/L of rhenium detected inside the MIP, suggesting that over half of the rhenium was eluted through. The same was seen when the fifth was added, with the amount of rhenium being detected increasing by 2300mg/L. When the sixth analyte was added, the amount of rhenium detected fell by 1700mg/L. When the 8M HCl was used to remove the analyte, there was a decrease in the amount of rhenium being detected inside the MIP, with the quantity of rhenium decreasing by 7250mg/L; 1170mg/L; 710mg/L and 1490mg/L respectively for the four 8M HCl stages.

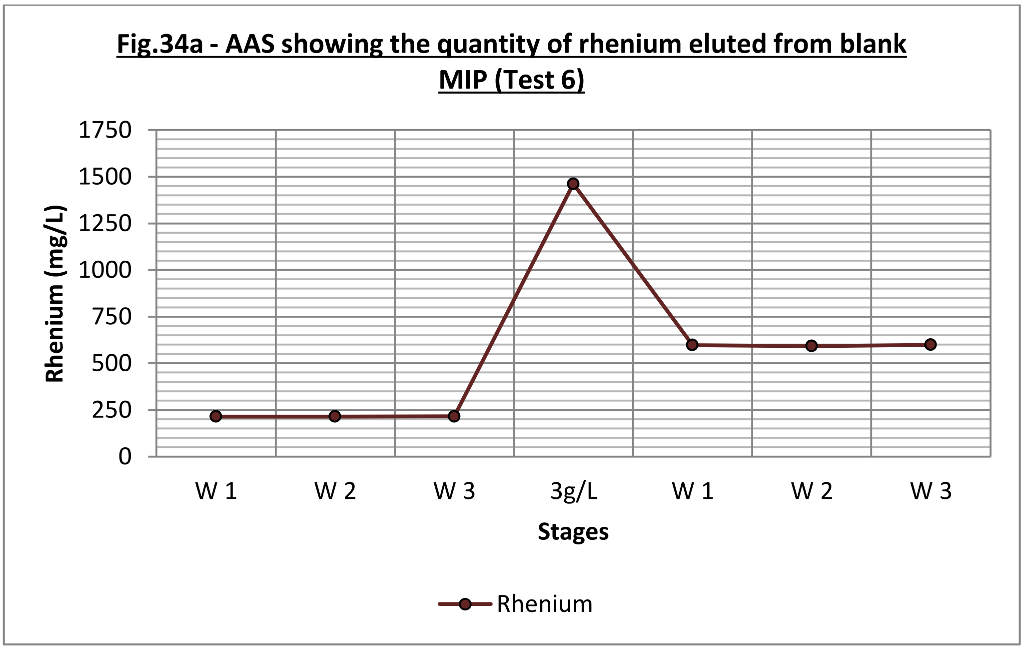
**Fig.33.2b - XRF showing the quantity of rhenium residue from MIP Test 5 (120mg) cont.**



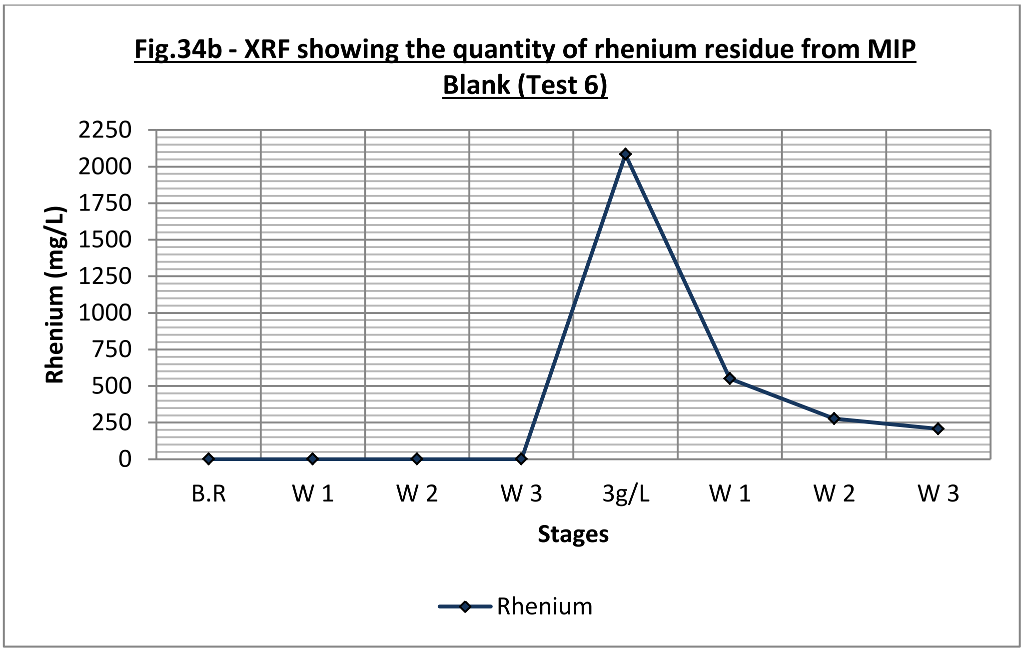

To see the XRF and AAS data, with along the calibration graph used for the AAS results, go to appendix 16.

### 3.3.6. Molecular Imprinted Polymer Test 6 (Blank)

Looking at Fig.34a and Fig.34b it shows that when the first lot of three washes with water was carried out (W1 - 3) the XRF detected no rhenium whereas the AAS detected on average 214.3mg/L of rhenium. When the 3000mg/L of ammonium perrhenate was added, the XRF detected 2083.33mg/L inside the MIP. This meant that 917mg/L should have been eluted. This is supported by the AAS data, as 1461.6mg/L of rhenium was detected in the eluted sample. When the three washes of water were used to rinse the MIP (after the analyte had been added) the amount of rhenium that was detected in the eluted sample was on average 596.13mg/L. After the three washes with water a total of 1788.4mg/L of rhenium had been detected in the eluted sample on the AAS. This means all the analyte had been removed.




The XRF data (Fig.34b) shows that after the first Wash (once the analyte had been added), 550mg/L was detected in the MIP. This dropped down to 206.67mg/L by the third was. The XRF data suggests that some of the rhenium was still inside the MIP after the three washes with water.



The fact that the results show that the analyte was removed by using water would indicate that that there were no interactions taking place between the MIP and analyte as it would be expected that the water would not be strong enough to remove the analyte if interactions were taking place. To look at the raw data for the XRF and AAS, along with the calibration graph used for the AAS results, go to appendix 17.

## 3.4. FTIR analysis of MIP samples

### 3.4.1. Pure Ammonium Perrhenate and Pure Potassium Perrhenate

Fig.35.1 - FTIR spectra showing pure ammonium and potassium perrhenate

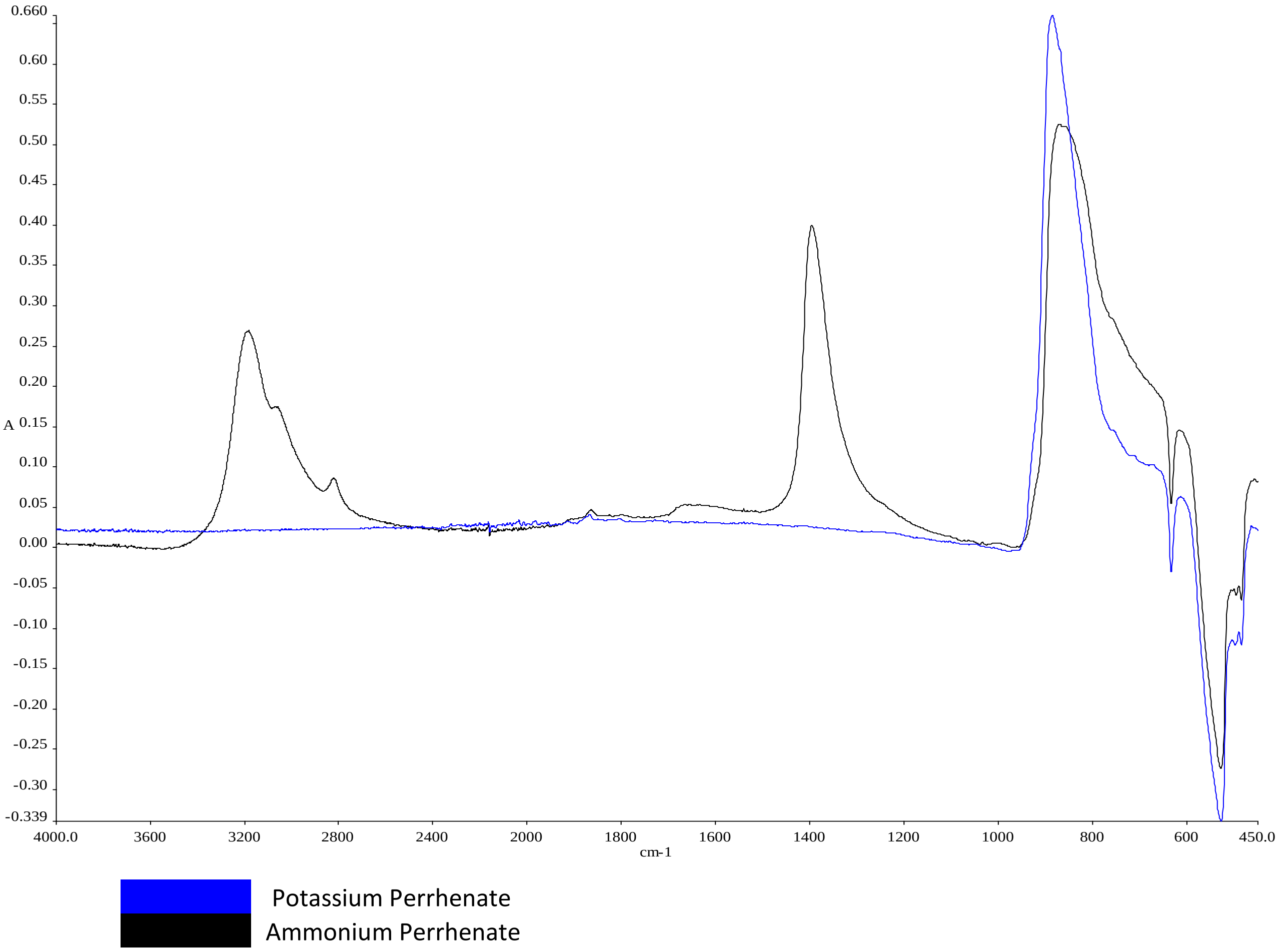
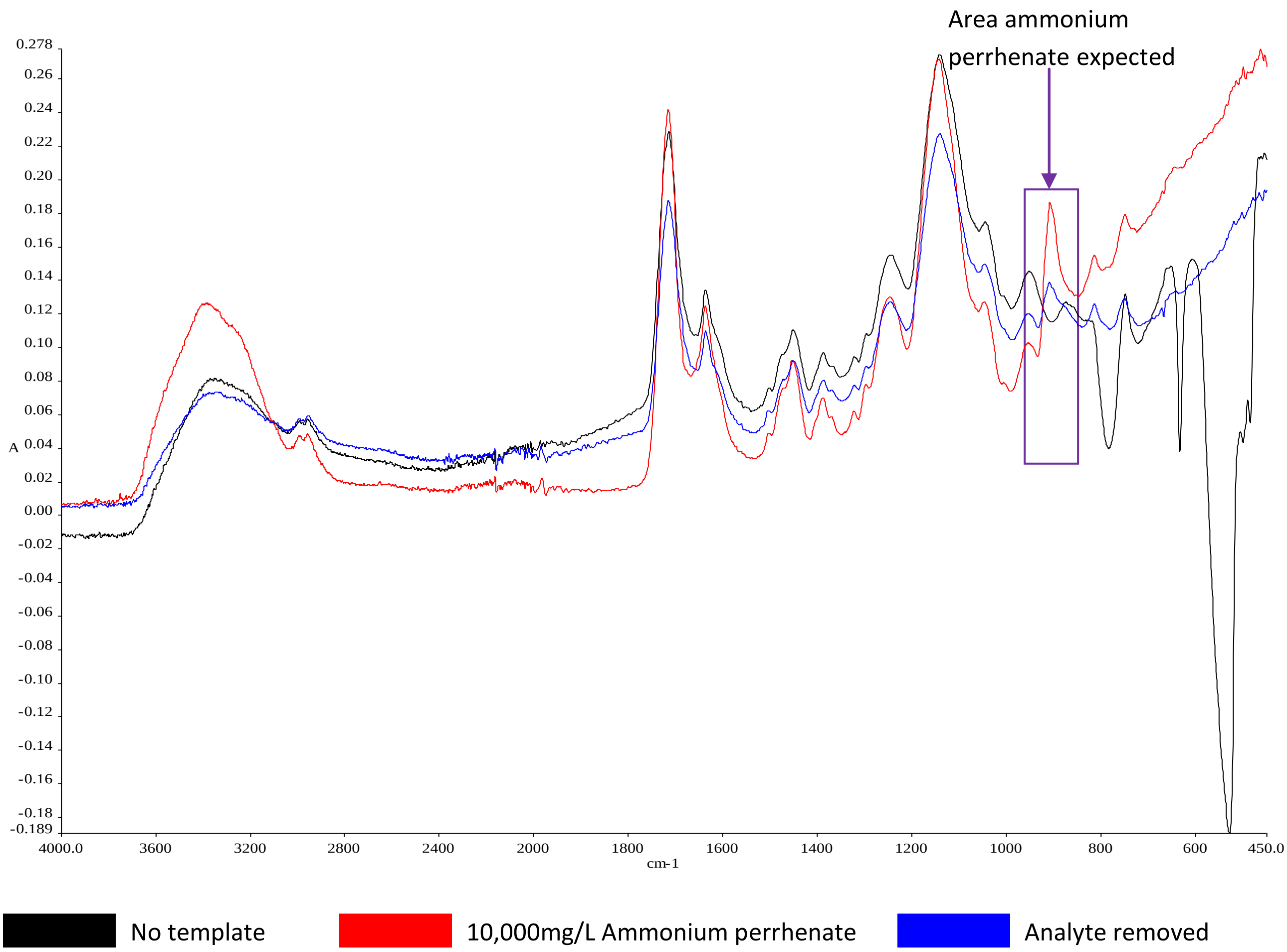



Fig.35.1 shows the difference between the potassium and ammonium perrhenate. Where there is a peak between 3200 and 2800 cm-1 on the ammonium perrhenate, this indicates the three stretching on the N-H bonds of the ammonium. The potassium perrhenate only has a peak at 800 cm-1 which is the same place the ammonium perrhenate has a peak. This indicates that the peak at 800cm-1 is the perrhenate as this is the only matching peak.

Therefore when looking at the other spectra of the samples, a peak around 800cm-1 would suggest the perrhenate is present.

### 3.4.2. Molecular Imprinted Polymer Test 3 (30mg template)

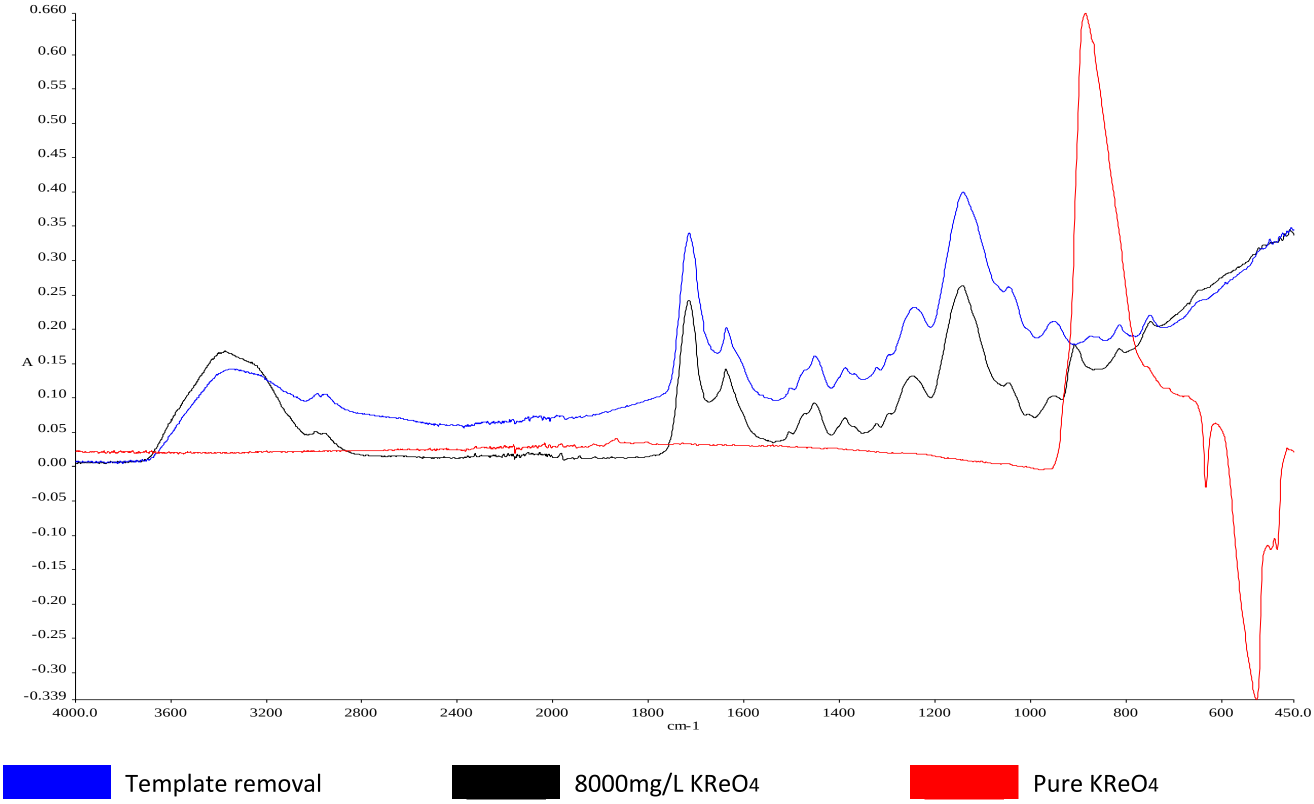
Fig.35.2 - FTIR spectra of the MIP test 3 without a template; with the addition of 10000mg/L ammonium perrhenate and with some of the analyte removed




The broad peak on Fig.35.2 all three spectra at 3600cm-1 is due to moisture still being present in the sample when being analysed. The small double peak at 3000cm-1 could be N-H stretching of amide groups. Although there is no distinct peak around 2000cm-1, the peaks that are present are C, N triple bond stretching from the 1,1'azobis(cyclohexanecarbonitrile).

The peaks at 1700cm-1 and 1600cm-1 are possible C, O double bond stretching from the EGDMA crosslinker molecule. The next peak along, at roughly 1500cm-1 are $CH_2$ bending of alkane groups from the 4-VP monomer. At roughly 1400cm-1 are $CH_3$ bending of alkane groups from the EGDMA crosslinker. At around 850cm-1 (area surrounded by a box and arrow), shows the spectra for the MIP without the template having no peak, however, once the 10000mg/L ammonium perrhenate had been added a peak appeared at the same place. After the MIP had been treated with 8M HCl to try and remove the analyte, the peak at 850cm-1 had decreased in its absorbance value. This is close to the 800cm-1 perrhenate peak observed on the pure ammonium perrhenate spectra. This indicates that ammonium perrhenate was present once it was added to the MIP and at least partial removal of the ammonium perrhenate was possible.

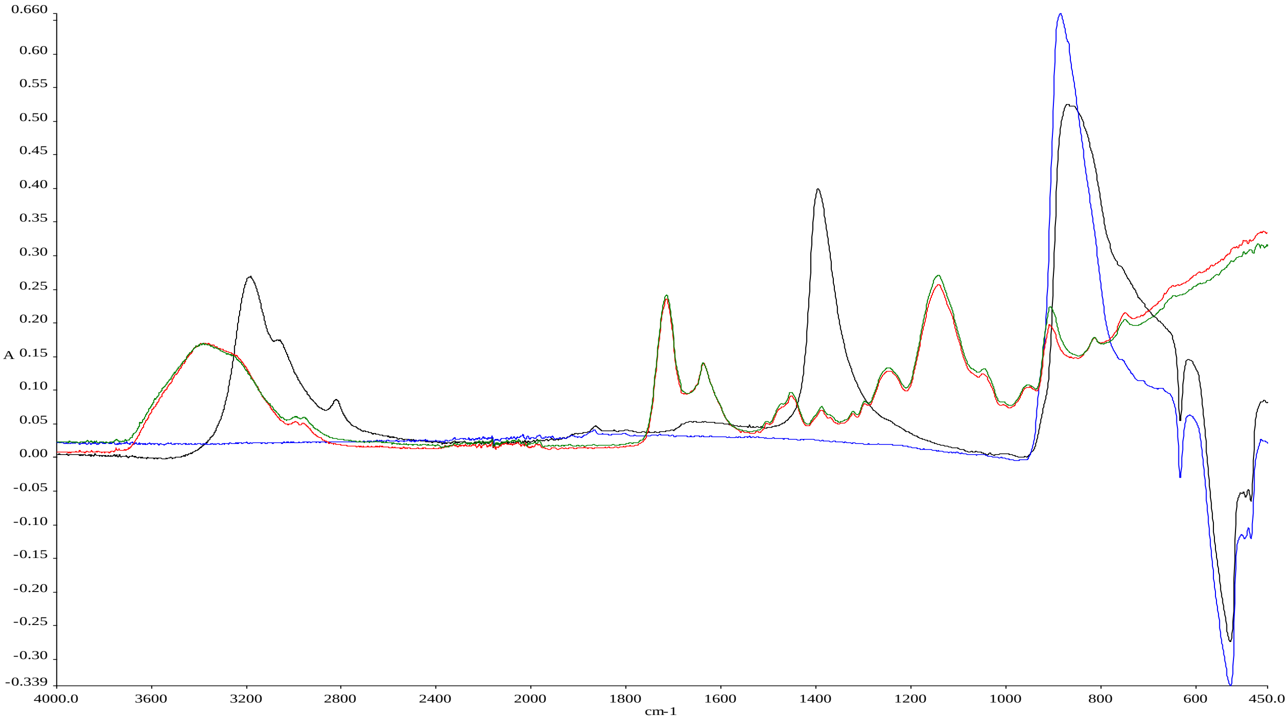
<u>Fig.35.3 - FTIR spectra of MIP test 3 when the template had been removed; when 8000mg/L of potassium perrhenate had been added and pure potassium perrhenate</u>




As mentioned above, the broad peak between 3600cm-1 and 3200cm-1 is due to moisture from the sample, which is why there is no peak for the pure potassium perrhenate as this sample was completely dry. Comparing the pure potassium perrhenate peak with the sample it is evident that when the template was removed there was no peak present however when 8000mg/L of potassium perrhenate had been added a small peak appeared. Despite it being slightly to the left of the pure potassium perrhenate peak, it was still within range to be considered as the perrhenate peak, indicating that perrhenate was within the sample. The peak of the potassium perrhenate in the MIP shifted due to the fact that it was interacting with the MIP and so was possibly restricted in its stretching; bending; or vibrating, whereas, the pure potassium perrhenate had the freedom to move to the excited state more easily as it was not restricted by the interacting of other molecules.

### 3.4.3. Molecular Imprinted Polymer Test 4 (60mg template)

Fig.35.4 -FTIR spectra of both pure ammonium and potassium perrhenate, along with the 10000mg/L ammonium perrhenate analyte and the 10000mg/L potassium perrhenate analyte




Pure NH4 ReO4
10,000ppm NH4ReO4 analyte
Pure KReO4
10,000ppm KReO4 analyte

The spectra for both the ammonium and potassium perrhenate analyte are very similar to that seen above from MIP Test 3 which indicates that the stretching and bending of bonds is the same for both MIP's, which is what would be expected. Looking at the perrhenate peak for the pure potassium and ammonium perrhenate samples and comparing them to the 10000mg/L potassium and ammonium perrhenate analyte, it is evident that both samples have produced a perrhenate peak in roughly the same place as the pure samples. This indicates that the perrhenate is within the MIP sample.

## 3.5. Testing of MIP selectivity with metal standards

### 3.5.1. Metal standards including rhenium

The metals used in the experiment were: aluminium, molybdenum, nickel, cobalt, tungsten and ammonium permeate.

Tantalum, Hafnium and Titanium were not used as they did not dissolve in aqua regia.

There was a total of 125mg/L of each metal in solution before the experiment was carried out.

The XRF was used after each stage of the pre-wash; loading and unloading of the MIP to detect what metals, if any, were inside the MIP. The XRF produced results in percentages and so these needed to be changed into mg/L. The metals that were detected and their averages are displayed in table 30.1.

Table 31.1 – Metals detected in the Molecular Imprinted Polymer

| Stage | Metal Detected | Average (mg/L) | Difference (mg/L) |
|---|---|---|---|
| Before Rinse | Rhenium | 3400 | |
| After Rinse | Rhenium | 890 | -2510 |
| 8M1 | Rhenium | 570 | -320 |
| 8M2 | Rhenium | 500 | -70 |
| 8M3 | Rhenium | 440 | -60 |
| 8M4 | Rhenium | 410 | -30 |
| 1ST 5ml filtered metal solution | Rhenium | 746.67 | +336.67 |
| 2nd 5ml filtered metal solution | Rhenium | 853.33 | +106.66 |
| Wash 1 | Rhenium | 880.00 | +26.67 |
| Wash 2 | Rhenium | 893.33 | +13.33 |
| Wash 3 | Rhenium | 893.33 | 0 |
| 8M1 | Rhenium | 526.67 | -366.66 |

As table 30.1 shows, there was a lot of loose rhenium in the MIP as 2510mg/L was removed in the rinse stage which used water. The first use of 8M HCl on the MIP removed 320mg/L of rhenium; however, the second to fourth time the 8M HCl was used, the amount of rhenium being removed each time was reduced. After the first 5ml solution containing any metals that were not captured on the filter paper was passed through the MIP, the amount of rhenium detected increased by 336.67mg/L, from 410mg/L to 746.67mg/L. After the second 5ml solution was added, there was only an increase of 106.66mg/L of rhenium. When the MIP was then rinsed with water again (wash 1-3) the results indicate that the rhenium was attached to the MIP as there was no loss in the amount of rhenium present in the MIP. If the rhenium had been loose in the MIP it would have been expected that the water would have been capable of removing the rhenium. When the 8M HCl was used again to try and remove the added rhenium, the first elution removed 366.66mg/L of rhenium, which was similar to the 320mg/L that was removed previously when the first elution using 8M HCl took place.

Before the first rinse, arsenic, gold and tantalum were also detected and tantalum was detected throughout. These elements are due to be contamination as they were not used in the experiment.

The metal solution was filtered before passing through the MIP. Table 30.2 shows the metals that were detected by the XRF on the filter paper. The results have been converted from percentage to mg/L and averages have been used.

Table 31.2 – Metals detected on the filter paper

| Stage | Metal detected | Average (mg/L) |
|---|---|---|
| Precipitated metal | Chromium | 603.33 |
| | Cobalt | 2470.00 |
| | Nickel | 2170.00 |
| | Molybdenum | 303.33 |
| | Tungsten | 2086.67 |

The results show that over 2000mg/L of cobalt, nickel and tungsten were detected on the filter paper, suggesting that most, if not all of the metal had been trapped on the filter. Chromium and molybdenum have lower values which could suggest that some of the metal filtered through and went through the MIP without being captured as there was no indication of either of the metals in the MIP from the XRF analysis. Despite aluminium being used in the experiment, the XRF did not detect aluminium on the filter paper nor in the MIP;

the reason for which is unknown. Tantalum was again detected on the filter paper but this is down to contamination as the metal was not used in the experiment.

### 3.5.2. Metal Standards not including rhenium

The same metals were used as above, with the absence of ammonium perrhenate. There was a concentration of 159.36mg/L of each metal in solution before the experiment was carried out.

Using the XRF to identify what metals, if any, were left on the filter paper indicated that a lot of metals were present. Table 31.1 shows what metals were identified and at what concentration.

Table 32.1 – Metals identified on filter paper

| Stage | Metal detected | Average (mg/L) |
|---|---|---|
| Precipitated metal | Chromium | 1350.00 |
| | Cobalt | 3536.67 |
| | Nickel | 2950.00 |
| | Molybdenum | 296.67 |
| | Tungsten | 2780.00 |
| | Tantalum | 135.00 |
| | Titanium | 1920.00 |
| | Gold | 20.00 |

The results show that there was a high concentration of chromium, nickel, cobalt and tungsten present on the filter paper with 1350mg/L; 2950mg/L; 3536.67mg/L and 2780mg/L respectively. Due to the high concentration it suggests that most, if not all of the chromium, nickel, cobalt and tungsten were captured on the filter paper. The molybdenum had a much lower concentration to the rest of the metals at 296.67mg/L which suggests some of the metal went through the filter and so was in the solution when it was passed through the MIP. Tantalum, titanium and gold were all contaminates.

Before the filtered metal solution was passed through the MIP, the template needed to be removed by using 8M HCl. The XRF was used to identify what metals were present in the MIP after each stage. Table 31.2a and table 31.2b show the metals that were detected.

Table 32.2a – Metals identified in the Molecular Imprinted Polymer

| Stage | Metal Detected | Average (mg/L) | Difference (mg/L) |
|---|---|---|---|
| 8M14 | - | - | - |
| 1st 5ml filtered metal solution | Molybdenum | 30.00 | +30.00 |
| 2nd 5ml filtered metal solution | Molybdenum | 93.33 | +63.33 |
| 3rd 5ml filtered metal solution | Molybdenum | 153.33 | +60.00 |
| 4th 5ml filtered metal solution | Molybdenum | 180.00 | +26.67 |
| Wash 1 | Molybdenum | 173.33 | -6.67 |
| Wash 2 | Molybdenum | 170.00 | -3.33 |
| Wash 3 | Molybdenum | 173.33 | +3.33 |
| 8M1 | Molybdenum | 170.00 | -3.33 |
| 8M2 | Molybdenum | 170.00 | 0.00 |
| 8M3 | Molybdenum | 163.33 | +6.67 |

Both molybdenum and rhenium were detected by the XRF. Table 31.2a focuses on the molybdenum and shows when the last 8M of HCl was used (8M14) there was no molybdenum present. Once the filtered metal solution was passed through the MIP, the amount of molybdenum that was detected increased to 30mg/L. The 2nd and 3rd addition of the filtered solution showed an increase of molybdenum by 65.33mg/L and 60mg/L respectively. Another 26.67mg/L of molybdenum was detected after the 4th filtered solution was passed through the MIP, giving a total of 180mg/L of molybdenum present in the MIP. The MIP was then washed with water three times and unexpectedly the molybdenum only decreased slightly, from 180mg/L to 173.33mg/L after the three washes. When HCl was used, a lower than expected amount of molybdenum was removed with the total amount of molybdenum in the MIP only dropping to 16.33mg/L after three HCl elution's.

Even though rhenium was not used in this experiment, it was still detected by the XRF at every stage. At 8M14, which was the last elution to try and remove the template, there was still 283.33mg/L of rhenium present. Once the first addition of the filtered metal solution was added, the amount of rhenium increased dramatically to 503.33mg/L. After the last three additions of the filtered solution had been passed through the MIP the amount of rhenium present dropped to 373.33mg/L. The three washes showed that the amount of rhenium did not decrease when only water was used. When the HCl started to be used (8M1 to 8M3) the amount of rhenium detected fell from 463.33mg/L down to 140mg/L. Table 21.2b shows these results.

Table 32.2b – Metals detected in MIP

| Stage | Metal Detected | Average (mg/L) | Difference (mg/L) |
|---|---|---|---|
| 8M14 | Rhenium | 283.33 | - |
| 1st 5ml filtered metal solution | Rhenium | 503.33 | +220.00 |
| 2nd 5ml filtered metal solution | Rhenium | 440.00 | -63.33 |
| 3rd 5ml filtered metal solution | Rhenium | 396.67 | -43.33 |
| 4th 5ml filtered metal solution | Rhenium | 373.33 | -23.34 |
| Wash 1 | Rhenium | 483.33 | +110.00 |
| Wash 2 | Rhenium | 463.33 | -20.00 |
| Wash 3 | Rhenium | 463.33 | 0.00 |
| 8M1 | Rhenium | 216.67 | -246.66 |
| 8M2 | Rhenium | 170.00 | -46.67 |
| 8M3 | Rhenium | 140.00 | -30.00 |

Tantalum was also detected throughout the experiment by the XRF, however this metal was not used in the experiment so was contamination.

## 4. Discussion

### 4.1. Interpretation of results

#### 4.1.1. Dissolution of Individual metals in Aqua Regia

Looking at the results of the individual metals, it was evident that tantalum and hafnium did not dissolve in the aqua regia. This was probably due to their unique properties which allow them to withstand the corrosive behaviour of the aqua regia. The tungsten metal created a yellow precipitate around the metal and only a small amount of tungsten actually dissolved. The reason for this was probably because tungsten oxide was formed which created a barrier that the aqua regia could not penetrate. The super alloy acted in a similar way to the tungsten. Even though 47.41% of the super alloy dissolved, eventually a coating (probably of aluminium oxide) formed which prevented the alloy to dissolve further. This coating however was fairly fragile and was removed easily, therefore, the use of ultra sonic during the dissolution process may have been enough to remove to coating and so allow for further dissolution of the alloy. Despite rhenium's distinct properties, it was one of the easiest metals to dissolve, with diluted volumes of aqua regia being able to fully dissolve the metal, especially when the ultra sonic bath was also used. The ultra sonic bath probably helped as the sonic waves agitate the liquid which produces high forces that interact with the metal, helping the metal break down. The agitated liquid would also explain why there was a higher temperature observed when the ultra sonic bath was used as the diluted aqua regia molecules had higher kinetic energy due to the sonic waves and so warmed up. The metals that got dissolved by the aqua regia could not withstand the oxidation properties of the nitric acid or the chlorine ions that were available from the hydrochloric acid.

#### 4.1.2. Rhenium Molecular Imprinted Polymers

The molecular imprinted polymers produced some promising results. It was evident from MIP Test 2 and 3 that the MIP's were able to be reused and even after the analyte had been added to the MIP and removed four times, there was no sign to suggest that the loading capacity of the MIPs were diminishing. This suggests that even though relatively high concentration of Hydrochloric Acid was being used, the acid was not destroying the matrix of the MIP. If the HCl was having a negative impact on the integrity of the polymer matrix, it would have been expected that the MIP would lose its ability to capture the analyte as the structure of the polymer would be compromised.

The reason MIP test 1 was not tested after the first loading of the ammonium perrhenate analyte was because it was the most unreliable as it produced three anomalies from the XRF results during the template removal (Fig.28.1b). MIP Test 2 was tested on further, along with test 3 to compare the difference between having the template dissolved during polymerisation (MIP Test 3) and having the template not dissolved beforehand (MIP Test 2). Despite the slight difference in methodology, they both produced similar results which were not expected. It was expected that the MIP test 2 which did not have the ammonium perrhenate template dissolved would have not captured as much analyte as not of all the template was incorporated in the polymer matrix. Because of this, it meant that MIP Test 4 and 5 were also produced using the method of dissolving the template in water to avoid any template from sitting at the bottom of the vial after polymerisation.

An interesting observation was that the MIPs seemed to capture much more analyte than expected. For example, it would have been expected that MIP test 4, which contained 60mg template would have had a maximum loading of around 60mg for the analyte, however this was not the case as the MIP could capture almost 15000mg/L. One possible reason for the increase in analyte capture could be because during the polymerisation, the water layer at the top, containing the dissolved template, started to evaporate which would have results in the increase in template concentration. The concentration of the template kept increasing as the water was being evaporated off until the template had no choice but to move into the organic polymer phase. This increase in concentration could have resulted in the increased analyte capture.

The theory behind the creation of MIP test 5, which contained 120mg of ammonium perrhenate template, was that, if MIP test 4 could capture 15000mg/L of analyte, then doubling the amount of template would mean the amount of analyte being captured would double (to 30000mg/L). This was not the case as after 9000mg/L of analyte being added, the amount of rhenium captured in the eluted solution rose considerably, suggesting the MIP had reached near its loading capacity. This may have been because of the polymerisation process as it was evident that the MIP was not as homogenous as it could be and so maybe the sample of MIP that was tested did not have as many binding sites as other areas of the MIP that was not tested on.

It was evident when looking at MIP Test 1 – 4 results that when the lower moles of HCl were used (1 – 6M) there seemed to be a point where the amount of template being removed started to plateau (when looking at the AAS results). The reason for this could have been that the template/analyte was bonded to the MIP at different strengths, therefore, when the 1M HCl was used, the weakest bonded molecules broke away, leaving behind the molecules that were more strongly bound. Then when the 3M HCl was used, it removed the molecules that were not as strongly bound as others and so on. The 8M HCl seemed to remove a lot of template/analyte without starting to plateau so for that reason it ended up being used instead of the lower concentrations of HCl.

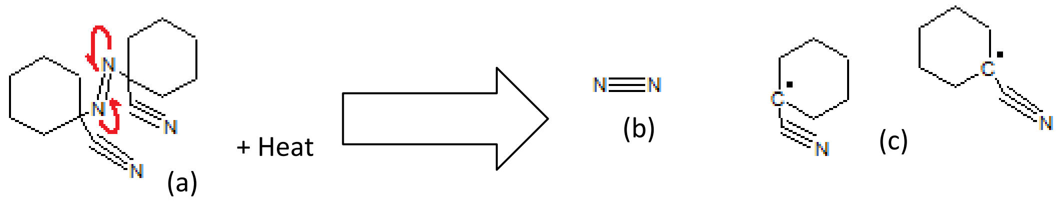
The results would suggest that the analyte was being molecularly bound to the MIPs, as when the water was used to rinse the MIPs after the analyte had been added, the amount of analyte detected did not seem to drop which would have been expected if the analyte was just sitting within the MIP. This is further supported by the blank MIP which had most of the analyte removed by the rinsing of the water, indicating that the analyte was not bound to the MIP which had no binding sites (as no template was used).

#### 4.1.3. FTIR analysis of MIP

Looking at the spectra of the MIP's it can help give an indication of how the polymer is formed. It was evident that there was C,O double bond stretching at 1700cm-1 and 1600cm-1 which would have come from the EGDMA. This means that the monomer was not attached to the C, O bond as it would have become a single bond. This means that the cross linkers and monomers attached to the $CH_2$ double bond on the EGDMA. With this in mind, along with how free radicals are formed and behave, it is possible to draw a picture of how the MIP probably formed during the polymerisation process.

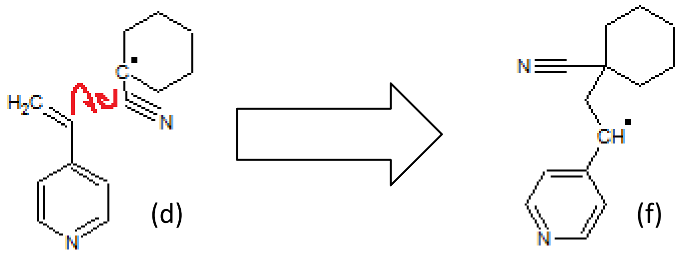
### 4.1.3.1. Polymerisation Process

As the solution heats up, the 1,1' azo(biscyclohexancarbonitrile) initiator breaks its bonds between the C-N (a) forming a Nitrogen-Nitrogen triple bond (b) and two free radicals (c).

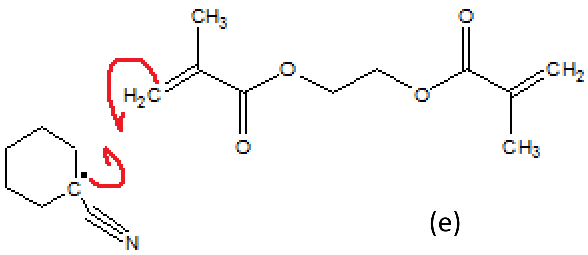


(a) (b) (c)

The free radicals start a chain reaction where they take three different routes: They interact with them self, therefore terminating the reaction; they interact with the C-C double bond of the functional monomer (4-VP) (d); or they interact with the C-C double bond of the cross-linker (EGDMA) (e). When the free radical reacts with the 4-VP it creates a free radical on the C-H bond of the 4-VP (f).

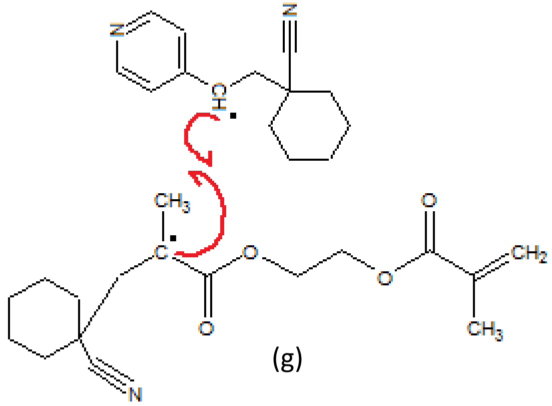

(d) (f)

The free radical (c) also interacts with the cross linker, joining together with it and forming a free radical on the cross linker on the carbon atom (e). The free radical (c) can interact with both C-C double bonds which are located on either end of the EGDMA.


(e)

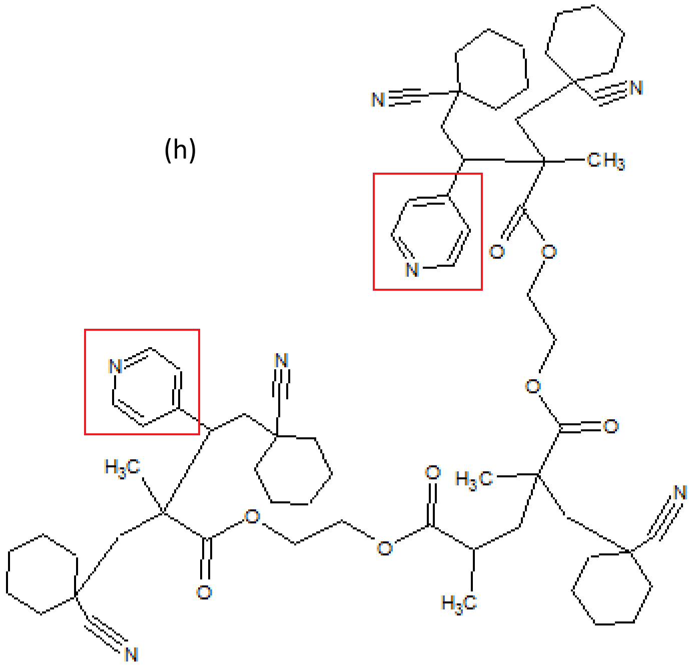
Now that the 4-VP and EGDMA have become free radicals, they can now either join with themselves or join with each other.

When the EGDMA and 4-VP join together (g), the cross linker is there to hold the 4-VP in place. The process of the EGDMA joining with itself and with the 4-VP results in a sturdy structure of cross linkers (EGDMA) holding the functional monomer (4-VP) in place (h) which allows the functional monomer (highlighted in a red square) to interact with the template (Ammonium Perrhenate).



(g)

(h)



When looking at the FTIR spectra in the results section it was evident that the perrhenate was present. This however does not determine if the analyte was molecularly bound to the MIP or if it was just mixed within the MIP but not actually attached.

#### 4.1.4. Preliminary MIP metal selectivity

Looking at experiment four it suggested that there was some selectivity towards rhenium even with other metals present. The XRF data suggested that there may have potentially been some molybdenum and chromium in the filtered solution as well as the ammonium perrhenate because the quantity of these two metals was lower than the other metals (Table 20.2, page 140). Despite the possible present of these two metals, rhenium was the only metal detected in the MIP (apart from the tantalum contaminate). All the metals, apart from the ammonium perrhenate and some of the molybdenum and chromium precipitated when the solution was neutralised. The dissolved metals were in an acidic solution with molybdenum and tungsten being dissolved in 0.1M ammonia and nickel; cobalt; aluminium; chromium dissolved in 1M nitric acid ($NHO_3$). Ammonium perrhenate was dissolved in water. The metals that were dissolved in nitric acid probably attached themselves to the nitrate ($NO_3$), creating dissolved nickel nitrate ($NiNO_3$); cobalt nitrate ($CoNO_3$); aluminium nitrate ($AlNO_3$) and chromium nitrate ($CrNO_3$). Tungsten and molybdenum most likely had ammonia ligands attached to themselves. The hydrogen from the nitric acid is what caused the solution to become acidic. When the sodium hydroxide (with the hydroxide making the solution alkali) was added to the acid metal solution the hydroxide molecules attached to the hydrogen molecules in the acid solution to produce water, turning the pH to 7. At the same time the nitrate on the metals detached from the metals and the hydroxide molecules from the sodium hydroxide, apart from combining to make water, also attached to the metals to make an insoluble salt containing the metals.

When the ammonium perrhenate was not used in the experiment molybdenum was detected inside the MIP and when acid was used to remove the molybdenum, it was very hard to do so. This suggests that the molybdenum may have bonded to the MIP which would suggest the selectivity may not be as good when ammonium perrhenate is not present.

Unfortunately the eluted samples could not be run on the AAS due to time restrictions. If they had been, it may have given more detail into exactly which metals were being passed through the MIP.

## 4.2. Method and Preparation of Experiments

### 4.2.1. Dissolution of Individual metals in Aqua Regia

During the set up of the experiment, there were a few areas of the method where problems were encountered. One of the problems was that there were not three pieces of molybdenum; tantalum; cobalt and rhenium, which meant the metal could not be tested in each strength of aqua regia. To overcome this problem the molybdenum and cobalt where cut with an electric tool which had a diamond coated blade attached. This was used to cut through the pieces of metal to create three pieces. Cutting through the molybdenum was fairly easy and took around 30 minutes to cut three pieces. The cobalt however, took much longer; around 45 minutes just to cut one piece. The tool was used on the tantalum to try and cut it. This was not achievable and even though the tool made a small mark on the metal, it did not manage to cut through it. Sparks came off the metal when trying to cut it and it just wore away at the diamond coating on the blade. For this reason only the one piece of tantalum was used throughout the experiment. The reason rhenium was only run in the 14.15% and 5% aqua regia was because the pieces of metal were too small to cut and due to cost it was only possible to buy four pieces.

Another problem encountered with the method was when placing the metal into and taking the metal out of the aqua regia. Due to aqua regia being corrosive to metals, it was not possible to use metal tweezers to hold the pieces of metal. Therefore, two glass rods were used initially to remove the metals from the solution at the end of the experiment. This was problematic as it was not always possible to grab them easily. Plastic tweezers were purchased which meant that the glass rods were not needed anymore and because the aqua regia did not attack the plastic it meant the pieces of metal could be picked up easily when in the aqua regia.

#### 4.2.2. Rhenium Molecular Imprinted Polymers

When making MIP Test 1 and 2, the template was not dissolved in water. This was a problem and became evident after the polymerisation as the ammonium perrhenate; an inorganic compound did not dissolve in the organic polymer solution. This meant that a proportion of the template was left at the bottom of the polymer after polymerisation (Fig.36). To try and overcome this problem, the rest of the MIP's (Test 3-6) had their template dissolved in water first. The problem with this was that the water was an inorganic compound and so formed a layer at the top of the organic polymer solution. Despite this, there was no evidence of non-dissolved template at the bottom of the polymer.

Fig.36 - Template at the bottom of the MIP Test 1 and 2

##### 4.2.2.1. Homogenising the sample

After polymerisation, it was evident that the polymer was not homogenous. Looking at the polymer the core seemed to be white, whereas the rest of the sample was an orange colour (Fig.37). A way to have fixed this would have possibly been to mix the dissolved ammonium perrhenate and water with methanol or ethanol. Using the alcohol would have possibly helped in bringing the organic and inorganic phases together and therefore allowing the template to be evenly distributed within the polymer. To help with the homogenising of the sample, the MIP's were ground down to fine particles to increase the surface area and help in potently trapping the analyte of interest.

Fig.37 - The white core in the MIP

#### 4.2.2.2. Molecular Imprinted Polymer Cartridges

A problem with the methodology of the cartridges was when placing the top frit inside the cartridge to hold the MIP in place. Using a glass rod, the frit was pushed down the tube of the cartridge, trying to push down in the centre of the frit. This however resulted in the frit turning on its side and so had to be removed a couple of times before it would insert correctly. An alternative method which worked slightly better was using tweezers to push the frit down by putting pressure on the edge of the frit instead of the centre.

When the solutions were being passed through the MIP, which was encased in the SPE cartridge, the rate at which the solution flowed varied. A pattern seemed to emerge where when the MIP was dry; the first elution went through within 5minutes however after this, the time increased to 10 – 20minutes for 5ml of solution to be passed through, despite being attached to a vacuum pump.

#### 4.2.3. FTIR analysis of MIP

One of the main problems with the method was that the solution needed to be constantly stirred to ensure that when the template/analyte was being removed it did not get reattached to the MIP which may have occurred if the solution was not constantly moving. The way this was achieved was using a glass rod and manually stirring. This is not ideal as it meant the stirring was not at a constant speed. Having an electric stirrer would have been better and more reliable.

Another problem was when testing the MIP, even though it was left to dry, it was evident by the FTIR results that not all the moisture had been removed. This also meant that the MIP's appearance had changed and instead of looking like grains, it looked fluffier. This made it harder to place the sample on the FTIR and screw down the clamp to get a good distribution of sample over the analyse window. It usually took a few attempts to get enough sample to cover the window.

#### 4.2.4. Preliminary MIP metal selectivity

During the process of changing the pH of the solution from acidic to neutral using sodium hydroxide (an alkali solution) it was difficult to get the solution to neutral because such small quantities of solutions were being used. One drop too many changed the solution from acidic to alkali and so to overcome this, the sodium hydroxide was added one drop at a time and the pH was tested after each drop. A slightly larger volume of metal solution was used the second time to help eliminate the difficulties faced with the first volume of metal solution.

When the metal solution was being filtered it was observed that when there was less volume of solution, the rate at which the solution went through the filter paper decreased dramatically and it took over 20minutes for all the solution to be filtered through. The solution was being filtered without the use of a pump as it was not possible to attach one to the beaker that was collecting the solution. If it had been possible the time it took for the solution to be filtered would have dropped considerably.

### 4.3. Analytical Techniques

#### 4.3.1. X-Ray Fluorescence

Both the AAS and XRF had their advantages and disadvantages. One of the biggest advantages with the XRF was that it could be used on the solid sample without being destructive towards the sample and it yielded results within 30 seconds. One of the problems with the XRF was that it was difficult to scan the sample in the exact same spot every time, which meant there could have been slight variations in the results. It was also evident that at times the XRF produced results that were much higher than the true value, for example, when MIP test 2 had 3000mg/L of ammonium perrhenate analyte added, which should have given an XRF value of around 3000mg/L, it instead produced a result of 18500mg/L. Another disadvantage of the XRF was that it could not test the eluted solution to see how much of the rhenium was being collected. Finally, the XRF seemed to detect a lot of contamination within the sample as a vast amount of elements that were not used in the experiment were detected. The Thermo Scientific Niton XL2 XRF Analyzer GOLDD, which was used at the beginning, detected a lot of contamination whereas when the Thermo Scientific Niton XL3t XRF Analyzer was used, the amount of elements detected fell to only one or two suggesting the anomalies were a result of the XRF being used and not the samples themselves.

### 4.3.2. Atomic Absorption Spectroscopy

Both the graphite furnace and flame setting was used on the AAS for this project. Looking at the furnace, one of the biggest problems encountered was that because it detects levels in the ppb a lot of the samples being analysed were too concentrated and so they had to be diluted down further. The furnace produced spectrums of the sample and so it was possible to determine if the samples were too concentrated as the peak would change. To see the difference between a normal spectrum and one with a high concentrated sample go to appendix 18. When the sample was too concentrated, 'roll over' occurred, which is when not all of the sample gets atomised, and so some is left over to the next testing of the sample, resulting in inaccurate results. Another disadvantage with the furnace was that it took nine minutes to run one sample, compared to the 30seconds for the XRF to produce a result. This meant that using the furnace was very time consuming when there were a lot of samples to be tested. Despite the length of time it took for the furnace to run a sample, the automated system was a big advantage as it meant the samples could be set up in the auto sampler and the AAS would run the samples without having to be watched.

The flame setting was a much faster technique for gaining results. It would take under one minute to get the result, however the samples had to be run manually and so this was time consuming when there were a lot of samples to run, furthermore, the flame setting did not produce any visual spectrums which could have been examined. Problems occurred with regards to the rhenium samples where not all the sample would be atomised and so a build up of rhenium around the burner head was inevitable (Fig.38) which could have led to inaccurate results. To eliminate this, the recommended conditions for running the Nitrous Oxide/Acetylene flame on the rhenium samples was adjusted so the flow of acetylene was 6.8L/min instead of 7.4L/min. This meant that the flame was hotter and so the entire sample got atomised. Another advantage of the flame was that it could read higher concentrations of sample (ppm) and so the more concentrated sample did not have to be diluted further. This however was also a disadvantage as it meant that any sample that was in the ppb range that could not be run on the furnace setting, were not detected by the flame.

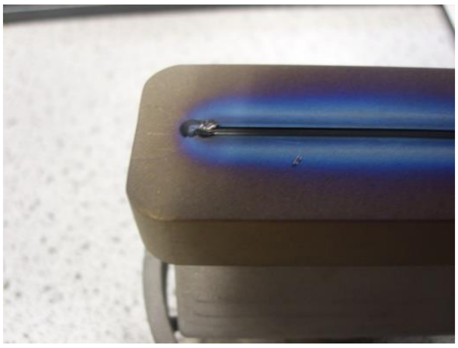


Fig.38 - Rhenium on the burner head

4.3.2.1 Atomic Absorption Spectroscopy Hollow Cathode Lamps

The AAS is a very element specific instrument which has its advantages in being able to gain results for the specific element of interest. This however can have a negative impact as it relies on having an element specific hallow cathode lamp. If there is not a working lamp for the element that needs to be analysed, then the analysis cannot be conducted. This was the case for the molybdenum, tantalum and hafnium. The lamps were available but could not produce enough light energy to use for analysis. This also became a problem with the rhenium lamp. It worked at the beginning of the experiments, but after a while, the energy of the lamp started to diminish and so results were not being produced. This eventually resulted in delaying the analysis of the rhenium samples as a new rhenium lamp had to be purchased. If there is a large variation in the energy of the lamp this can also have an effect on the results as the higher energy produces more accurate results, especially at lower concentrations. Furthermore, the hallow cathode lamps produce a noise signal which becomes more extreme as the lamp gets older. This background noise can interfere with results, especially at low concentrations. Due to this, it is very probable that the low concentrations of rhenium samples (around 50mg/L (50000mg/L after the dilution factor is removed) or less) produced a result from the background noise of the lamp and not from the sample itself.

4.3.3 FTIR

Compared to the AAS and XRF, the FTIR is the most useful of the analytical techqniues used. Although the FTIR had its disadvantages, as mentioned previously, it would have been beneficial if the technique had been used more. The reason for this is because the FTIR looks at the whole molecule and so can give a detailed understanding of how the MIP is interacting with all the components. The AAS and XRF on the other hand, could only give information on the individual elements, which is useful to see what elements were present, but is limited in the fact that they cannot identify if the elements present in the MIP was down to interactions with the MIP, trapping the elements.

**4.4. Could the MIP be profitable at an industrial scale?**

If the molecular imprinted polymer test 4 (which contained 60mg template) is looked at (as it gave the most accurate results and largest maximum loading capacity) it is possible to determine if this MIP would be profitable and beneficial at an industrial scale.

MIP test 4 managed to trap 15000mg/L of analyte which is equivalent to 75mg of perrhenate in 1g of MIP. This means that currently the MIP can produce a 7.5% yield of analyte. This may not sound a lot but it can still be profitable. Making MIP's are relatively cheap to produce and to make 1kg of MIP with a 60mg template it would cost £543.54. In the current market ammonium perrhenate is roughly £2500 for 1kg which means if 75g of perrhenate can be collected from 1kg of MIP there would be £187.50 worth of perrhenate for every 75g collection. Due to the evidence that the MIP can be re-used, after three runs there would be a profit of £18.96 which would increase to £187.50 for every run thereafter. If the analyte was purified to be more than 99% ammonium perrhenate then the price at which the product could be sold would increase dramatically as in the current market ≥99% ammonium perrhenate is sold for £281.50 for 25g (figure obtained from SigmaAldrich.com). This would mean that 75g could be sold for £844.50.

**5. Conclusions**

The results have produced some interesting conclusions. Using aqua regia to dissolve metals does appear to work best when pure aqua regia is used however it was possible to dissolve rhenium in slightly diluted aqua regia which could be beneficial when trying to separate rhenium from super alloys. The results also showed that it was possible to dissolve some of the super alloy, however a protective layer formed and so this would need to be eliminated in order to carry on with the dissolution. The use of the ultra sonic bath would be the possible answer to help remove the protective layer. Looking at aqua regia over a seven day period also showed that the rate at which the aqua regia lost its potency towards the different metals varied from a few hours to a few days. This is beneficial to know as it means when dissolving metals the aqua regia may not need to be re-made at such frequent intervals, making the use of aqua regia more efficient.

Both the XRF and AAS data, even though they varied slightly when looking at the molecular imprinted polymer samples, did generally support each other. The results showed real potential that the MIPs were able to capture the analyte as hydrochloric acid had to be used to remove it, suggesting that there was some molecular bonding occurring. The results also showed that the analyte could be removed and the MIPs could be reused and even after MIP test 2 and 3 had the analyte added and removed four times there was no sign of the polymers loading capabilities decreasing. MIP test 4 showed that it was possible to trap 15000mg/L of analyte which, if introduced into an industrial scale process, could produce a profit (after three runs) of £187.50 for each consecutive run.

The FTIR results showed that the perrhenate analyte was present within the MIP, however this did not confirm if the analyte was being trapped or was just mixed within the MIP. Looking at the selectivity of MIP test 4, it appeared that when ammonium perrhenate was present the MIP selected the correct analyte, however when ammonium perrhenate was not used, molybdenum seemed to be trapped inside the MIP and was hard to remove, even with 8M HCl. When the metal acid solution was neutralised, most of the dissolved metals precipitated and were captured on filter paper.

The XRF was a very quick and non-destructive instrument which was a big advantage, however some of the results were much higher than the true value and also the XRF could not be used on the liquid sample which was a disadvantage.

Even though the AAS was a rather slow technique to use when the graphite furnace was needed, it was very sensitive and could detect levels down to µg/L. The flame setting was a much faster technique, however could only detect sample concentrations down to mg/L. The biggest disadvantage with the AAS was that it relied heavily on hollow cathode lamps that were working well and any that weren't meant results at low concentrations could have been affected by the lamps background noise, or the samples could not be analysed.

The methodology for the four experiments worked well with only a few problems encountered, however the problems should not have affected the results obtained.

## 5.1. Recommendations for further work

### 5.1.1 Dissolution of individual metals

Looking at further work to be carried out, more could have been done with the dissolution of metals. Due to time restriction, only the rhenium metal was tested using the ultra sonic bath. All the other nine metals could be tested using the ultra sonic bath as well. This would help determine if using ultra sonic speeds up the rate at which the individual metals dissolve. The piece of super alloy could also be tested using the ultra sonic bath to see if the vibrations from the ultra sonic would break down the aluminium oxide barrier which possibly contributed to the slow rate of dissolution.

Testing the super alloy CMSX-4 in the two diluted solutions of aqua regia (14.15% and 5% $HNO_3$) would help to conclude whether diluted aqua regia would work as effectively as pure aqua regia in dissolving the super alloy.

The three metals that did not dissolve (Titanium, Hafnium, Tantalum) could be investigated further to see if it is possible to dissolve them with the right conditions. One possibility would be to see if heating the aqua regia would allow the metals to dissolve. Trying to dissolve the metals using the ultra sonic bath would also be an area to investigate.

### 5.1.2. Molecular Imprinted Polymers

An important area to look into is to improve the effectiveness of the rhenium molecular imprinted polymer. One of the problems during the making of the MIP was that there were two phases in solution, investigating how to eliminate the separation could result in a very efficient MIP with a much larger extraction yield and homogenous sample. A process that

may eliminate the separation would be to possibly use an alcohol like ethanol or methanol which can mix with both the organic and inorganic phases.
If there had been more time it would have been a possibility to make more than just the rhenium MIP. If MIP's were made for the other metals in the super alloy, then it would help in the clean up steps before extracting the rhenium from the dissolved super alloy.
Furthermore, searching the published literature, it does not appear that MIP's have ever been made for the metals aluminium or molybdenum therefore investigating if they are possible to create would be a novel area to explore.
In this study the MIP was compacted into a solid phase extraction cartridge when being used. An area to look at would be to see if different conditions would produce better results. For example, having the MIP lose, not compacted may be more beneficial in trapping the analyte of interest. Having the MIP lose was touched upon in this study; however more detailed investigations need to be carried out to determine its effectiveness.
In this study the repeatability of the MIP had been looked at briefly to see how many times the MIP could be re-used before the extraction yield starts to deteriorate. Ideally, if there had been more time than more re-runs would have been tested until a conclusion could be made as to how many cycles could be run on a MIP before it stopped working.
Further work regarding the molecular imprinted polymer would include trying to upscale the size of the MIP's to a size that would be practical in an industrial setting. This should only be done once the effectiveness and yield of the MIP's have been maximised.

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# 7. Appendices

## 7.1. Appendix 1 - Calculations for Hydrochloric Acid Molar concentrations

200ml solution needed.

Stock solution of HCl is 12M.

| Molar Concentration (M) | Equation | HCl volume (ml) | Water volume (ml) |
|---|---|---|---|
| 1M | (1x200)/12 | 16.67 | 183.33 |
| 3M | (3x200)/12 | 50 | 150 |
| 6M | (6x200)/12 | 100 | 100 |
| 8M | (8x200)/12 | 133.33 | 66.67 |

## 7.2.1. Appendix 2a - Calculation for the concentration of metal solution in experiment four

Equation: volume of metal x concentration = weight of metal

weight of metal / total volume = concentration

- 2ml of each metal was used and each metal was 1000mg/L concentration.
- 16ml (0.016L) of solution in total.

2ml*1000mg/1000ml = 2mg of each metal

2mg/0.016L = <u>125mg/L</u> in solution

## 7.2.2. Appendix 2b - Calculation for the concentration of metal solution in experiment four

Equation: volume of metal x concentration = weight of metal

weight of metal / total volume = concentration

- 4ml of each metal was used and each metal was 1000mg/L concentration.
- 25.1ml (0.0251L) of solution in total.

4ml*1000mg/1000ml = 4mg of each metal

4mg/0.0251L = <u>159.36mg/L</u> in solution

### 7.3.1. Appendix 3a - Nickel Calibration graph raw data

| Concentration (ppb) | BlnkCorr | Peak Area | Peak Height |
|---|---|---|---|
| water | 0.004 | 0.0044 | 0.0035 |
| | 0.0026 | 0.0026 | 0.0039 |
| | 0.0027 | 0.0027 | 0.0031 |
| Average | 0.0031 | 0.0032 | 0.0035 |
| SD | 0.0008 | 0.0010 | 0.0004 |
| RSD% | 25.19 | 31.29 | 11.43 |
| 20 | 0.0848 | 0.0880 | 0.1128 |
| | 0.0891 | 0.0923 | 0.1161 |
| | 0.0942 | 0.0975 | 0.1207 |
| Average | 0.0894 | 0.0926 | 0.1165 |
| SD | 0.0047 | 0.0048 | 0.0040 |
| RSD% | 5.2656 | 5.1373 | 3.4049 |
| 40 | 0.1671 | 0.1703 | 0.2109 |
| | 0.1676 | 0.1708 | 0.2078 |
| | 0.1693 | 0.1726 | 0.2107 |
| Average | 0.1680 | 0.1712 | 0.2098 |
| SD | 0.0012 | 0.0012 | 0.0017 |
| RSD% | 0.6865 | 0.7065 | 0.8269 |
| 60 | 0.2409 | 0.2441 | 0.2906 |
| | 0.2470 | 0.2502 | 0.2946 |
| | 0.2420 | 0.2452 | 0.2881 |
| Average | 0.2433 | 0.2465 | 0.2911 |
| SD | 0.0033 | 0.0033 | 0.0033 |
| RSD% | 1.3363 | 1.3189 | 1.1263 |
| 80 | 0.3127 | 0.3159 | 0.3554 |
| | 0.3155 | 0.3187 | 0.3587 |
| | 0.3156 | 0.3188 | 0.3597 |
| Average | 0.3146 | 0.3178 | 0.3579 |
| SD | 0.0016 | 0.0016 | 0.0023 |
| RSD% | 0.5233 | 0.5180 | 0.6287 |
| 100 | 0.3806 | 0.3839 | 0.4157 |
| | 0.3803 | 0.3836 | 0.4134 |
| | 0.3870 | 0.3902 | 0.4203 |
| Average | 0.3826 | 0.3859 | 0.4165 |
| SD | 0.0038 | 0.0037 | 0.0035 |
| RSD% | 0.9891 | 0.9658 | 0.8436 |

### 7.3.2. Appendix 3b - Nickel AAS raw data

**5% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 | BlnkCorr Signal | | 0.0026 | 0.0035 | 0.0028 | 0.0030 | 0.0005 | 15.93 |
| | Peak Area | | 0.0026 | 0.0035 | 0.0028 | 0.0030 | 0.0005 | 15.93 |
| | Peak Height | | 0.0034 | 0.0036 | 0.0030 | 0.0033 | 0.0003 | 9.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 R | BlnkCorr Signal | | 0.0027 | 0.0027 | 0.0024 | 0.0026 | 0.0002 | 6.66 |
| | Peak Area | | 0.0027 | 0.0027 | 0.0024 | 0.0026 | 0.0002 | 6.66 |
| | Peak Height | | 0.0029 | 0.0034 | 0.0031 | 0.0031 | 0.0003 | 8.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 2 | BlnkCorr Signal | | 0.0013 | 0.0015 | 0.0018 | 0.0015 | 0.0003 | 16.41 |
| | Peak Area | | 0.0013 | 0.0015 | 0.0018 | 0.0015 | 0.0003 | 16.41 |
| | Peak Height | | 0.0022 | 0.0027 | 0.0035 | 0.0028 | 0.0007 | 23.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 3 | BlnkCorr Signal | | 0.0018 | 0.0021 | 0.0023 | 0.0021 | 0.0003 | 12.18 |
| | Peak Area | | 0.0018 | 0.0021 | 0.0023 | 0.0021 | 0.0003 | 12.18 |
| | Peak Height | | 0.0029 | 0.0032 | 0.0030 | 0.0030 | 0.0002 | 5.04 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 4 | BlnkCorr Signal | | 0.0028 | 0.0023 | 0.0029 | 0.0027 | 0.0003 | 12.05 |
| | Peak Area | | 0.0028 | 0.0023 | 0.0029 | 0.0027 | 0.0003 | 12.05 |
| | Peak Height | | 0.0032 | 0.0026 | 0.0041 | 0.0033 | 0.0008 | 22.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 5 | BlnkCorr Signal | | 0.0018 | 0.0021 | 0.0033 | 0.0024 | 0.0008 | 33.07 |
| | Peak Area | | 0.0018 | 0.0021 | 0.0033 | 0.0024 | 0.0008 | 33.07 |
| | Peak Height | | 0.0031 | 0.0031 | 0.0034 | 0.0032 | 0.0002 | 5.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 6 | BlnkCorr Signal | | 0.0058 | 0.0049 | 0.0056 | 0.0054 | 0.0005 | 8.70 |
| | Peak Area | | 0.0058 | 0.0049 | 0.0056 | 0.0054 | 0.0005 | 8.70 |
| | Peak Height | | 0.0045 | 0.0043 | 0.0052 | 0.0047 | 0.0005 | 10.13 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 0 | BlnkCorr Signal | | 0.0080 | 0.0076 | 0.0080 | 0.0079 | 0.0002 | 2.94 |
| | Peak Area | | 0.0080 | 0.0076 | 0.0080 | 0.0079 | 0.0002 | 2.94 |
| | Peak Height | | 0.0065 | 0.0070 | 0.0065 | 0.0067 | 0.0003 | 4.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 2.5 | BlnkCorr Signal | | 0.0086 | 0.0085 | 0.0090 | 0.0087 | 0.0003 | 3.04 |
| | Peak Area | | 0.0086 | 0.0085 | 0.0090 | 0.0087 | 0.0003 | 3.04 |
| | Peak Height | | 0.0069 | 0.0062 | 0.0080 | 0.0070 | 0.0009 | 12.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 5 | BlnkCorr Signal | | 0.0087 | 0.0079 | 0.0086 | 0.0084 | 0.0004 | 5.19 |
| | Peak Area | | 0.0087 | 0.0079 | 0.0086 | 0.0084 | 0.0004 | 5.19 |
| | Peak Height | | 0.0067 | 0.0064 | 0.0067 | 0.0066 | 0.0002 | 2.62 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 7.5 | BlnkCorr Signal | | 0.0081 | 0.0077 | 0.0078 | 0.0079 | 0.0002 | 2.65 |
| | Peak Area | | 0.0081 | 0.0077 | 0.0078 | 0.0079 | 0.0002 | 2.65 |
| | Peak Height | | 0.0069 | 0.0066 | 0.0070 | 0.0068 | 0.0002 | 3.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 0 | BlnkCorr Signal | | 0.0108 | 0.0115 | 0.0121 | 0.0115 | 0.0007 | 5.67 |
| | Peak Area | | 0.0108 | 0.0115 | 0.0121 | 0.0115 | 0.0007 | 5.67 |
| | Peak Height | | 0.0090 | 0.0095 | 0.0088 | 0.0091 | 0.0004 | 3.96 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 3.5 | BlnkCorr Signal | | 0.0569 | 0.0573 | 0.0572 | 0.0571 | 0.0002 | 0.36 |
| | Peak Area | | 0.0569 | 0.0573 | 0.0572 | 0.0571 | 0.0002 | 0.36 |
| | Peak Height | | 0.0398 | 0.0413 | 0.0413 | 0.0408 | 0.0009 | 2.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 7 | BlnkCorr Signal | | 0.0592 | 0.0620 | 0.0664 | 0.0625 | 0.0036 | 5.80 |
| | Peak Area | | 0.0592 | 0.0620 | 0.0664 | 0.0625 | 0.0036 | 5.80 |
| | Peak Height | | 0.0412 | 0.0460 | 0.0470 | 0.0447 | 0.0031 | 6.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 0 | BlnkCorr Signal | | 0.0693 | 0.0704 | 0.0696 | 0.0698 | 0.0006 | 0.82 |
| | Peak Area | | 0.0693 | 0.0704 | 0.0696 | 0.0698 | 0.0006 | 0.82 |
| | Peak Height | | 0.0496 | 0.0498 | 0.0508 | 0.0501 | 0.0006 | 1.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 7 | BlnkCorr Signal | | 0.0711 | 0.0808 | 0.0816 | 0.0778 | 0.0058 | 7.51 |
| | Peak Area | | 0.0711 | 0.0808 | 0.0816 | 0.0778 | 0.0058 | 7.51 |
| | Peak Height | | 0.0511 | 0.0573 | 0.0584 | 0.0556 | 0.0039 | 7.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 | BlnkCorr Signal | | 0.0847 | 0.0871 | 0.0884 | 0.0867 | 0.0019 | 2.16 |
| | Peak Area | | 0.0845 | 0.0871 | 0.0884 | 0.0867 | 0.0020 | 2.31 |
| | Peak Height | | 0.0582 | 0.0588 | 0.0609 | 0.0593 | 0.0014 | 2.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.0907 | 0.0904 | 0.0887 | 0.0899 | 0.0011 | 1.20 |
| | Peak Area | | 0.0907 | 0.0904 | 0.0887 | 0.0899 | 0.0011 | 1.20 |
| | Peak Height | | 0.0613 | 0.0623 | 0.0615 | 0.0617 | 0.0005 | 0.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 0 | BlnkCorr Signal | | 0.0951 | 0.0970 | 0.1009 | 0.0977 | 0.0030 | 3.03 |
| | Peak Area | | 0.0951 | 0.0970 | 0.1009 | 0.0977 | 0.0030 | 3.03 |
| | Peak Height | | 0.0643 | 0.0659 | 0.0692 | 0.0665 | 0.0025 | 3.76 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 7 | BlnkCorr Signal | | 0.0974 | 0.0967 | 0.1036 | 0.0992 | 0.0038 | 3.83 |
| | Peak Area | | 0.0974 | 0.0967 | 0.1036 | 0.0992 | 0.0038 | 3.83 |
| | Peak Height | | 0.0654 | 0.0663 | 0.0708 | 0.0675 | 0.0029 | 4.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.1043 | 0.1060 | 0.1067 | 0.1057 | 0.0012 | 1.17 |
| | Peak Area | | 0.1043 | 0.1060 | 0.1067 | 0.1057 | 0.0012 | 1.17 |
| | Peak Height | | 0.0691 | 0.0700 | 0.0710 | 0.0700 | 0.0010 | 1.36 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.1075 | 0.1093 | 0.1140 | 0.1103 | 0.0034 | 3.04 |
| | Peak Area | | 0.1075 | 0.1093 | 0.1140 | 0.1103 | 0.0034 | 3.04 |
| | Peak Height | | 0.0701 | 0.0718 | 0.0763 | 0.0727 | 0.0032 | 4.40 |

## 14.15% aqua regia sample raw data

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 | BlnkCorr Signal | | 0.0068 | 0.0073 | 0.0083 | 0.0075 | 0.0008 | 10.23 |
| | Peak Area | | 0.0068 | 0.0073 | 0.0083 | 0.0075 | 0.0008 | 10.23 |
| | Peak Height | | 0.0067 | 0.0060 | 0.0069 | 0.0065 | 0.0005 | 7.23 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 R | BlnkCorr Signal | | 0.0077 | 0.0073 | 0.0068 | 0.0073 | 0.0005 | 6.21 |
| | Peak Area | | 0.0077 | 0.0073 | 0.0068 | 0.0073 | 0.0005 | 6.21 |
| | Peak Height | | 0.0067 | 0.0066 | 0.0064 | 0.0066 | 0.0002 | 2.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 2 | BlnkCorr Signal | | 0.0110 | 0.0119 | 0.0110 | 0.0113 | 0.0005 | 4.60 |
| | Peak Area | | 0.0110 | 0.0119 | 0.0110 | 0.0113 | 0.0005 | 4.60 |
| | Peak Height | | 0.0093 | 0.0092 | 0.0088 | 0.0091 | 0.0003 | 2.91 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 3 | BlnkCorr Signal | | 0.0179 | 0.0183 | 0.0191 | 0.0184 | 0.0006 | 3.31 |
| | Peak Area | | 0.0179 | 0.0183 | 0.0191 | 0.0184 | 0.0006 | 3.31 |
| | Peak Height | | 0.0125 | 0.0130 | 0.0128 | 0.0128 | 0.0003 | 1.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 4 | BlnkCorr Signal | | 0.0669 | 0.0686 | 0.0684 | 0.0680 | 0.0009 | 1.37 |
| | Peak Area | | 0.0669 | 0.0686 | 0.0684 | 0.0680 | 0.0009 | 1.37 |
| | Peak Height | | 0.0421 | 0.0419 | 0.0408 | 0.0416 | 0.0007 | 1.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 5 | BlnkCorr Signal | | 0.0317 | 0.0296 | 0.0285 | 0.0299 | 0.0016 | 5.43 |
| | Peak Area | | 0.0317 | 0.0296 | 0.0285 | 0.0299 | 0.0016 | 5.43 |
| | Peak Height | | 0.0198 | 0.0184 | 0.0179 | 0.0187 | 0.0010 | 5.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 6 | BlnkCorr Signal | | 0.0335 | 0.0336 | 0.0339 | 0.0337 | 0.0002 | 0.62 |
| | Peak Area | | 0.0335 | 0.0336 | 0.0339 | 0.0337 | 0.0002 | 0.62 |
| | Peak Height | | 0.0221 | 0.0223 | 0.0266 | 0.0237 | 0.0025 | 10.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 0 | BlnkCorr Signal | | 1.2861 | 1.3445 | 1.3702 | 1.3336 | 0.0431 | 3.23 |
| | Peak Area | | 1.2861 | 1.3445 | 1.3702 | 1.3336 | 0.0431 | 3.23 |
| | Peak Height | | 0.5816 | 0.5935 | 0.5957 | 0.5903 | 0.0076 | 1.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 2.5 | BlnkCorr Signal | | 0.0660 | 0.0691 | 0.0692 | 0.0681 | 0.0018 | 2.67 |
| | Peak Area | | 0.0660 | 0.0691 | 0.0692 | 0.0681 | 0.0018 | 2.67 |
| | Peak Height | | 0.0392 | 0.0410 | 0.0401 | 0.0401 | 0.0009 | 2.24 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 5 | BlnkCorr Signal | | 0.0883 | 0.0862 | 0.0837 | 0.0861 | 0.0023 | 2.68 |
| | Peak Area | | 0.0883 | 0.0862 | 0.0837 | 0.0861 | 0.0023 | 2.68 |
| | Peak Height | | 0.0439 | 0.0485 | 0.0491 | 0.0472 | 0.0028 | 6.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 7.5 | BlnkCorr Signal | | 0.0934 | 0.0942 | 0.0935 | 0.0937 | 0.0004 | 0.47 |
| | Peak Area | | 0.0934 | 0.0942 | 0.0935 | 0.0937 | 0.0004 | 0.47 |
| | Peak Height | | 0.0561 | 0.0557 | 0.0556 | 0.0558 | 0.0003 | 0.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 0 | BlnkCorr Signal | | 0.1405 | 0.1442 | 0.1448 | 0.1432 | 0.0023 | 1.63 |
| | Peak Area | | 0.1405 | 0.1442 | 0.1448 | 0.1432 | 0.0023 | 1.63 |
| | Peak Height | | 0.0844 | 0.0849 | 0.0857 | 0.0850 | 0.0007 | 0.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 3.5 | BlnkCorr Signal | | 0.1509 | 0.1513 | 0.1517 | 0.1513 | 0.0004 | 0.26 |
| | Peak Area | | 0.1509 | 0.1513 | 0.1517 | 0.1513 | 0.0004 | 0.26 |
| | Peak Height | | 0.0889 | 0.0892 | 0.0907 | 0.0896 | 0.0010 | 1.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 7 | BlnkCorr Signal | | 0.1704 | 0.1704 | 0.1735 | 0.1714 | 0.0018 | 1.04 |
| | Peak Area | | 0.1704 | 0.1704 | 0.1735 | 0.1714 | 0.0018 | 1.04 |
| | Peak Height | | 0.1006 | 0.1003 | 0.1020 | 0.1010 | 0.0009 | 0.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 0 | BlnkCorr Signal | | 0.2293 | 0.2313 | 0.2351 | 0.2319 | 0.0029 | 1.27 |
| | Peak Area | | 0.2293 | 0.2313 | 0.2351 | 0.2319 | 0.0029 | 1.27 |
| | Peak Height | | 0.1351 | 0.1354 | 0.1376 | 0.1360 | 0.0014 | 1.00 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 | BlnkCorr Signal | | 0.2718 | 0.2715 | 0.2666 | 0.2700 | 0.0029 | 1.08 |
| | Peak Area | | 0.2718 | 0.2715 | 0.2666 | 0.2700 | 0.0029 | 1.08 |
| | Peak Height | | 0.1600 | 0.1587 | 0.1539 | 0.1575 | 0.0032 | 2.04 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 | BlnkCorr Signal | | 0.2863 | 0.2917 | 0.2911 | 0.2897 | 0.0030 | 1.02 |
| | Peak Area | | 0.2863 | 0.2917 | 0.2911 | 0.2897 | 0.0030 | 1.02 |
| | Peak Height | | 0.1668 | 0.1706 | 0.1669 | 0.1681 | 0.0022 | 1.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.2975 | 0.2944 | 0.2978 | 0.2966 | 0.0019 | 0.63 |
| | Peak Area | | 0.2975 | 0.2944 | 0.2978 | 0.2966 | 0.0019 | 0.63 |
| | Peak Height | | 0.1716 | 0.1684 | 0.1728 | 0.1709 | 0.0023 | 1.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RR | BlnkCorr Signal | | 0.3021 | 0.2956 | 0.2988 | 0.2988 | 0.0033 | 1.09 |
| | Peak Area | | 0.3021 | 0.2956 | 0.2988 | 0.2988 | 0.0033 | 1.09 |
| | Peak Height | | 0.1746 | 0.1728 | 0.1749 | 0.1741 | 0.0011 | 0.65 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RRR | BlnkCorr Signal | | 0.2970 | 0.2992 | 0.2929 | 0.2964 | 0.0032 | 1.08 |
| | Peak Area | | 0.2970 | 0.2992 | 0.2929 | 0.2964 | 0.0032 | 1.08 |
| | Peak Height | | 0.1741 | 0.1733 | 0.1708 | 0.1727 | 0.0017 | 1.00 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 0 | BlnkCorr Signal | | 0.3771 | 0.3774 | 0.3801 | 0.3782 | 0.0017 | 0.44 |
| | Peak Area | | 0.3771 | 0.3774 | 0.3801 | 0.3782 | 0.0017 | 0.44 |
| | Peak Height | | 0.2170 | 0.2166 | 0.2170 | 0.2169 | 0.0002 | 0.11 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 7 | BlnkCorr Signal | | 0.4058 | 0.4061 | 0.4073 | 0.4064 | 0.0008 | 0.20 |
| | Peak Area | | 0.4058 | 0.4061 | 0.4073 | 0.4064 | 0.0008 | 0.20 |
| | Peak Height | | 0.2304 | 0.2286 | 0.2271 | 0.2287 | 0.0017 | 0.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.4514 | 0.4499 | 0.4489 | 0.4501 | 0.0013 | 0.28 |
| | Peak Area | | 0.4514 | 0.4499 | 0.4489 | 0.4501 | 0.0013 | 0.28 |
| | Peak Height | | 0.2514 | 0.2495 | 0.2503 | 0.2504 | 0.0010 | 0.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.4537 | 0.4481 | 0.4484 | 0.4501 | 0.0032 | 0.70 |
| | Peak Area | | 0.4537 | 0.4481 | 0.4484 | 0.4501 | 0.0032 | 0.70 |
| | Peak Height | | 0.2511 | 0.2498 | 0.2478 | 0.2496 | 0.0017 | 0.67 |

## 23.3% aqua regia sample raw data

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 | BlnkCorr Signal | | 0.0613 | 0.0642 | 0.0665 | 0.0640 | 0.0026 | 4.07 |
| | Peak Area | | 0.0613 | 0.0642 | 0.0665 | 0.0640 | 0.0026 | 4.07 |
| | Peak Height | | 0.3790 | 0.3920 | 0.4010 | 0.3907 | 0.0111 | 2.83 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 R | BlnkCorr Signal | | 0.0642 | 0.0660 | 0.0667 | 0.0656 | 0.0013 | 1.97 |
| | Peak Area | | 0.0642 | 0.0660 | 0.0667 | 0.0656 | 0.0013 | 1.97 |
| | Peak Height | | 0.0402 | 0.0397 | 0.0413 | 0.0404 | 0.0008 | 2.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 2 | BlnkCorr Signal | | 0.0861 | 0.0861 | 0.0878 | 0.0867 | 0.0010 | 1.13 |
| | Peak Area | | 0.0861 | 0.0861 | 0.0878 | 0.0867 | 0.0010 | 1.13 |
| | Peak Height | | 0.0520 | 0.0517 | 0.0537 | 0.0525 | 0.0011 | 2.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 3 | BlnkCorr Signal | | 0.1697 | 0.1720 | 0.1721 | 0.1713 | 0.0014 | 0.79 |
| | Peak Area | | 0.1697 | 0.0172 | 0.1721 | 0.1197 | 0.0887 | 74.16 |
| | Peak Height | | 0.1025 | 0.1020 | 0.1004 | 0.1016 | 0.0011 | 1.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 4 | BlnkCorr Signal | | 0.3225 | 0.3305 | 0.3376 | 0.3302 | 0.0076 | 2.29 |
| | Peak Area | | 0.3225 | 0.3305 | 0.3376 | 0.3302 | 0.0076 | 2.29 |
| | Peak Height | | 0.1878 | 0.1898 | 0.1947 | 0.1908 | 0.0036 | 1.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 5 | BlnkCorr Signal | | 0.6033 | 0.6164 | 0.6320 | 0.6172 | 0.0144 | 2.33 |
| | Peak Area | | 0.6033 | 0.6164 | 0.6320 | 0.6172 | 0.0144 | 2.33 |
| | Peak Height | | 0.3344 | 0.3410 | 0.3442 | 0.3399 | 0.0050 | 1.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 6 | BlnkCorr Signal | | 0.8002 | 0.8236 | 0.8101 | 0.8113 | 0.0117 | 1.45 |
| | Peak Area | | 0.8002 | 0.8236 | 0.8101 | 0.8113 | 0.0117 | 1.45 |
| | Peak Height | | 0.4236 | 0.4275 | 0.4255 | 0.4255 | 0.0020 | 0.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 0 | BlnkCorr Signal | | 1.3778 | 1.4091 | 1.4262 | 1.4044 | 0.0245 | 1.75 |
| | Peak Area | | 1.3778 | 1.4091 | 1.4262 | 1.4044 | 0.0245 | 1.75 |
| | Peak Height | | 0.6312 | 0.6373 | 0.6393 | 0.6359 | 0.0042 | 0.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 2.5 | BlnkCorr Signal | | 1.4661 | 1.4761 | 1.4600 | 1.4674 | 0.0081 | 0.55 |
| | Peak Area | | 1.4661 | 1.4761 | 1.4600 | 1.4674 | 0.0081 | 0.55 |
| | Peak Height | | 0.6442 | 0.6520 | 0.6505 | 0.6489 | 0.0041 | 0.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 5 | BlnkCorr Signal | | 1.5117 | 1.5033 | 1.5008 | 1.5053 | 0.0057 | 0.38 |
| | Peak Area | | 1.5117 | 1.5033 | 1.5008 | 1.5053 | 0.0057 | 0.38 |
| | Peak Height | | 0.6655 | 0.6616 | 0.6570 | 0.6614 | 0.0043 | 0.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 7.5 | BlnkCorr Signal | | 1.5478 | 1.5452 | 1.5538 | 1.5489 | 0.0044 | 0.28 |
| | Peak Area | | 1.5478 | 1.5452 | 1.5538 | 1.5489 | 0.0044 | 0.28 |
| | Peak Height | | 0.6704 | 0.6662 | 0.6750 | 0.6705 | 0.0044 | 0.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 0 | BlnkCorr Signal | | 1.6749 | 1.6695 | 1.6655 | 1.6700 | 0.0047 | 0.28 |
| | Peak Area | | 1.6749 | 1.6695 | 1.6655 | 1.6700 | 0.0047 | 0.28 |
| | Peak Height | | 0.6992 | 0.6996 | 0.6241 | 0.6743 | 0.0435 | 6.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 3.5 | BlnkCorr Signal | | 1.6888 | 1.7059 | 1.7007 | 1.6985 | 0.0088 | 0.52 |
| | Peak Area | | 1.6888 | 1.7059 | 1.7007 | 1.6985 | 0.0088 | 0.52 |
| | Peak Height | | 0.7009 | 0.7080 | 0.7071 | 0.7053 | 0.0039 | 0.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 7 | BlnkCorr Signal | | 1.7203 | 1.7114 | 1.7422 | 1.7246 | 0.0159 | 0.92 |
| | Peak Area | | 1.7203 | 1.7114 | 1.7422 | 1.7246 | 0.0159 | 0.92 |
| | Peak Height | | 0.7045 | 0.7067 | 0.7134 | 0.7082 | 0.0046 | 0.65 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 0 | BlnkCorr Signal | | 1.8407 | 1.8733 | 1.8852 | 1.8664 | 0.023038 | 1.23 |
| | Peak Area | | 1.8407 | 1.8733 | 1.8852 | 1.8664 | 0.023038 | 1.23 |
| | Peak Height | | 0.7263 | 0.7290 | 0.7312 | 0.7288 | 0.002454 | 0.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 7 | BlnkCorr Signal | | 1.8939 | 1.8927 | 1.8960 | 1.8942 | 0.0017 | 0.09 |
| | Peak Area | | 1.8939 | 1.8927 | 1.8960 | 1.8942 | 0.0017 | 0.09 |
| | Peak Height | | 0.7309 | 0.7388 | 0.7326 | 0.7341 | 0.0042 | 0.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 | BlnkCorr Signal | | 1.8289 | 1.8237 | 1.8228 | 1.8251 | 0.0033 | 0.18 |
| | Peak Area | | 1.8289 | 1.8237 | 1.8228 | 1.8251 | 0.0033 | 0.18 |
| | Peak Height | | 0.7235 | 0.7237 | 0.7272 | 0.7248 | 0.0021 | 0.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 R | BlnkCorr Signal | | 1.8260 | 2.0967 | 1.8439 | 1.9222 | 0.1514 | 7.88 |
| | Peak Area | | 1.8260 | 2.0967 | 1.8439 | 1.9222 | 0.1514 | 7.88 |
| | Peak Height | | 0.7265 | 0.7521 | 0.7231 | 0.7339 | 0.0159 | 2.16 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 0 | BlnkCorr Signal | | 1.9495 | 1.9721 | 1.9626 | 1.9614 | 0.0113 | 0.58 |
| | Peak Area | | 1.9495 | 1.9721 | 1.9626 | 1.9614 | 0.0113 | 0.58 |
| | Peak Height | | 0.7399 | 0.7381 | 0.7415 | 0.7398 | 0.0017 | 0.23 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 7 | BlnkCorr Signal | | 1.9987 | 2.0067 | 1.9872 | 1.9975 | 0.0098 | 0.49 |
| | Peak Area | | 1.9987 | 2.0067 | 1.9872 | 1.9975 | 0.0098 | 0.49 |
| | Peak Height | | 0.7361 | 0.7436 | 0.7396 | 0.7398 | 0.0038 | 0.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 2.0347 | 2.0340 | 2.0278 | 2.0322 | 0.0038 | 0.19 |
| | Peak Area | | 2.0347 | 2.0340 | 2.0278 | 2.0322 | 0.0038 | 0.19 |
| | Peak Height | | 0.7460 | 0.7452 | 0.7467 | 0.7460 | 0.0008 | 0.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 2.0254 | 2.0139 | 2.0342 | 2.0245 | 0.0102 | 0.50 |
| | Peak Area | | 2.0254 | 2.0139 | 2.0342 | 2.0245 | 0.0102 | 0.50 |
| | Peak Height | | 0.7523 | 0.7416 | 0.7421 | 0.7453 | 0.0060 | 0.81 |

### 7.3.3. Appendix 3c - Nickel Temperature raw data

**5% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 20.75 |
| | 2 | 20.00 |
| | 3 | 20.00 |
| | 4 | 20.50 |
| | 5 | 19.75 |
| | 6 | 19.50 |
| 2 | 24 | 18.00 |
| | 26.5 | 18.25 |
| | 29 | 19.50 |
| | 31.5 | 19.50 |
| 3 | 48 | 19.00 |
| | 51.5 | 20.50 |
| | 55 | 20.75 |
| 4 | 72 | 18.75 |
| | 79 | 20.25 |
| | **84.5** | 17.50 |
| 7 | 144 | 15.00 |
| | 151 | 17.75 |
| 8 | **168** | 19.50 |

**14.15% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 21.00 |
| | 2 | 21.00 |
| | 3 | 19.75 |
| | 4 | 20.50 |
| | 5 | 20.00 |
| | 6 | 19.50 |
| 2 | 24 | 18.00 |
| | 26.5 | 18.00 |
| | 29 | 19.50 |
| | 31.5 | 19.50 |
| 3 | 48 | 19.00 |
| | 51.5 | 20.50 |
| | 55 | 21.00 |
| 4 | 72 | 19.00 |
| | 79 | 20.50 |
| | **84.5** | 17.50 |
| 7 | 144 | 15.00 |
| | 151 | 18.00 |
| 8 | **168** | 19.50 |

**23.3% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 23.00 |
| | 2 | 22.00 |
| | 3 | 22.50 |
| | 4 | 22.50 |
| | 5 | 23.00 |
| | 6 | 22.75 |
| 2 | 24 | 18.75 |
| | 26.5 | 19.00 |
| | 29 | 20.25 |
| | 31.5 | 20.50 |

| Day | Hours | Temperature (°C) |
|---|---|---|
| 3 | 48 | 19.50 |
| | 51.5 | 21.25 |
| | 55 | 21.50 |
| 4 | 72 | 19.50 |
| | 79 | 21.00 |
| | **84.5** | 18.00 |
| 7 | 144 | 15.50 |
| | 151 | 18.50 |
| 8 | **168** | 20.00 |

### 7.4.1. Appendix 4a - Chromium Calibration graph raw data

range: 0.5 - 4 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (PA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 0.513 | 0.512 | 0.00058 | 0.11 |
| | 0.512 | | | |
| | 0.512 | | | |
| 0.5 | 0.024 | 0.024 | 0.00058 | 2.44 |
| | 0.023 | | | |
| | 0.024 | | | |
| 1 | 0.044 | 0.045 | 0.00100 | 2.23 |
| | 0.045 | | | |
| | 0.046 | | | |
| 2 | 0.091 | 0.090 | 0.00115 | 1.28 |
| | 0.091 | | | |
| | 0.089 | | | |
| 4 | 0.157 | 0.157 | 0.00100 | 0.64 |
| | 0.156 | | | |
| | 0.158 | | | |

range: 20 - 50 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (PA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 0.004 | 0.004 | 0.00000 | 0.00 |
| | 0.004 | | | |
| | 0.004 | | | |
| 20 | 0.335 | 0.291 | 0.04986 | 17.14 |
| | 0.237 | | | |
| | 0.302 | | | |
| 30 | 0.684 | 0.625 | 0.07240 | 11.58 |
| | 0.646 | | | |
| | 0.544 | | | |
| 40 | 0.835 | 0.838 | 0.00252 | 0.30 |
| | 0.840 | | | |
| | 0.838 | | | |
| 50 | 0.972 | 0.957 | 0.01286 | 1.34 |
| | 0.952 | | | |
| | 0.948 | | | |

### 7.4.2. Appendix 4b - Chromium AAS raw data

**5% aqua regia sample raw data**

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 | BlnkCorr Signal | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 0.139 | 0.127 | 0.131 | 0.132 | 0.0061 | 4.62 |
| | Stnd Conc (mg/L) | 0.139 | 0.127 | 0.131 | 0.132 | 0.0061 | 4.62 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 R | BlnkCorr Signal | 0.006 | 0.007 | 0.007 | 0.007 | 0.0006 | 8.66 |
| | sample conc (mg/L) | 0.131 | 0.145 | 0.152 | 0.143 | 0.0107 | 7.49 |
| | Stnd Conc (mg/L) | 0.131 | 0.145 | 0.152 | 0.143 | 0.0107 | 7.49 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 2 | BlnkCorr Signal | 0.006 | 0.006 | 0.007 | 0.006 | 0.0006 | 9.12 |
| | sample conc (mg/L) | 0.134 | 0.142 | 0.146 | 0.141 | 0.0061 | 4.34 |
| | Stnd Conc (mg/L) | 0.134 | 0.142 | 0.146 | 0.141 | 0.0061 | 4.34 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 3 | BlnkCorr Signal | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 0.150 | 0.154 | 0.150 | 0.151 | 0.0023 | 1.53 |
| | Stnd Conc (mg/L) | 0.150 | 0.154 | 0.150 | 0.151 | 0.0023 | 1.53 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 4 | BlnkCorr Signal | 0.008 | 0.007 | 0.005 | 0.007 | 0.0015 | 22.91 |
| | sample conc (mg/L) | 0.169 | 0.167 | 0.117 | 0.151 | 0.0295 | 19.51 |
| | Stnd Conc (mg/L) | 0.169 | 0.167 | 0.117 | 0.151 | 0.0295 | 19.51 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 5 | BlnkCorr Signal | 0.004 | 0.005 | 0.005 | 0.005 | 0.0006 | 12.37 |
| | sample conc (mg/L) | 0.081 | 0.112 | 0.107 | 0.100 | 0.0166 | 16.64 |
| | Stnd Conc (mg/L) | 0.081 | 0.112 | 0.107 | 0.100 | 0.0166 | 16.64 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 6 | BlnkCorr Signal | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 0.146 | 0.147 | 0.152 | 0.148 | 0.0032 | 2.17 |
| | Stnd Conc (mg/L) | 0.146 | 0.147 | 0.152 | 0.148 | 0.0032 | 2.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 0 | BlnkCorr Signal | | 0.006 | 0.006 | 0.004 | 0.005 | 0.0012 | 21.65 |
| | sample conc (mg/L) | | 0.137 | 0.131 | 0.092 | 0.120 | 0.0244 | 20.36 |
| | Stnd Conc (mg/L) | | 0.137 | 0.131 | 0.092 | 0.120 | 0.0244 | 20.36 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 2.5 | BlnkCorr Signal | | 0.007 | 0.007 | 0.006 | 0.007 | 0.0006 | 8.66 |
| | sample conc (mg/L) | | 0.153 | 0.159 | 0.144 | 0.152 | 0.0075 | 4.97 |
| | Stnd Conc (mg/L) | | 0.153 | 0.159 | 0.144 | 0.152 | 0.0075 | 4.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 5 | BlnkCorr Signal | | 0.006 | 0.007 | 0.007 | 0.007 | 0.0006 | 8.66 |
| | sample conc (mg/L) | | 0.139 | 0.158 | 0.162 | 0.153 | 0.0123 | 8.03 |
| | Stnd Conc (mg/L) | | 0.139 | 0.158 | 0.162 | 0.153 | 0.0123 | 8.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 7.5 | BlnkCorr Signal | | 0.006 | 0.007 | 0.007 | 0.007 | 0.0006 | 8.66 |
| | sample conc (mg/L) | | 0.139 | 0.153 | 0.153 | 0.148 | 0.0081 | 5.45 |
| | Stnd Conc (mg/L) | | 0.139 | 0.153 | 0.153 | 0.148 | 0.0081 | 5.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 0 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.162 | 0.157 | 0.160 | 0.160 | 0.0025 | 1.58 |
| | Stnd Conc (mg/L) | | 0.162 | 0.157 | 0.160 | 0.160 | 0.0025 | 1.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 3.5 | BlnkCorr Signal | | 0.008 | 0.007 | 0.005 | 0.007 | 0.0015 | 22.91 |
| | sample conc (mg/L) | | 0.170 | 0.142 | 0.102 | 0.138 | 0.0342 | 24.77 |
| | Stnd Conc (mg/L) | | 0.170 | 0.142 | 0.102 | 0.138 | 0.0342 | 24.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 7 | BlnkCorr Signal | | 0.006 | 0.007 | 0.008 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 0.129 | 0.156 | 0.172 | 0.152 | 0.0217 | 14.27 |
| | Stnd Conc (mg/L) | | 0.129 | 0.156 | 0.172 | 0.152 | 0.0217 | 14.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 0 | BlnkCorr Signal | | 0.008 | 0.007 | 0.008 | 0.008 | 0.0006 | 7.53 |
| | sample conc (mg/L) | | 0.170 | 0.162 | 0.174 | 0.169 | 0.0061 | 3.62 |
| | Stnd Conc (mg/L) | | 0.170 | 0.162 | 0.174 | 0.169 | 0.0061 | 3.62 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 7 | BlnkCorr Signal | | 0.007 | 0.007 | 0.006 | 0.007 | 0.0006 | 8.66 |
| | sample conc (mg/L) | | 0.161 | 0.157 | 0.140 | 0.153 | 0.0112 | 7.30 |
| | Stnd Conc (mg/L) | | 0.161 | 0.157 | 0.140 | 0.153 | 0.0112 | 7.30 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 | BlnkCorr Signal | | 0.006 | 0.008 | 0.008 | 0.007 | 0.0012 | 15.75 |
| | sample conc (mg/L) | | 0.142 | 0.170 | 0.187 | 0.166 | 0.0227 | 13.66 |
| | Stnd Conc (mg/L) | | 0.142 | 0.170 | 0.187 | 0.166 | 0.0227 | 13.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.165 | 0.165 | 0.166 | 0.165 | 0.0006 | 0.35 |
| | Stnd Conc (mg/L) | | 0.165 | 0.165 | 0.166 | 0.165 | 0.0006 | 0.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day5** hr 0 | BlnkCorr Signal | | 0.008 | 0.007 | 0.005 | 0.007 | 0.0015 | 22.91 |
| | sample conc (mg/L) | | 0.176 | 0.145 | 0.122 | 0.148 | 0.0271 | 18.35 |
| | Stnd Conc (mg/L) | | 0.176 | 0.145 | 0.122 | 0.148 | 0.0271 | 18.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day5** hr 7 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.179 | 0.187 | 0.181 | 0.182 | 0.0042 | 2.28 |
| | Stnd Conc (mg/L) | | 0.179 | 0.187 | 0.181 | 0.182 | 0.0042 | 2.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.008 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 0.186 | 0.200 | 0.196 | 0.194 | 0.0072 | 3.72 |
| | Stnd Conc (mg/L) | | 0.186 | 0.200 | 0.196 | 0.194 | 0.0072 | 3.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.009 | 0.008 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 0.191 | 0.188 | 0.193 | 0.191 | 0.0025 | 1.32 |
| | Stnd Conc (mg/L) | | 0.191 | 0.188 | 0.193 | 0.191 | 0.0025 | 1.32 |

## 14.15% aqua regia sample raw data

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.206 | 0.203 | 0.199 | 0.203 | 0.0035 | 1.73 |
| | Stnd Conc (mg/L) | | 0.206 | 0.203 | 0.199 | 0.203 | 0.0035 | 1.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 R | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.200 | 0.192 | 0.198 | 0.197 | 0.0042 | 2.12 |
| | Stnd Conc (mg/L) | | 0.200 | 0.192 | 0.198 | 0.197 | 0.0042 | 2.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 2 | BlnkCorr Signal | | 0.009 | 0.010 | 0.007 | 0.009 | 0.0015 | 17.63 |
| | sample conc (mg/L) | | 0.208 | 0.221 | 0.166 | 0.198 | 0.0287 | 14.49 |
| | Stnd Conc (mg/L) | | 0.208 | 0.221 | 0.166 | 0.198 | 0.0287 | 14.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 3 | BlnkCorr Signal | | 0.007 | 0.008 | 0.009 | 0.008 | 0.0010 | 12.50 |
| | sample conc (mg/L) | | 0.161 | 0.183 | 0.193 | 0.179 | 0.0164 | 9.15 |
| | Stnd Conc (mg/L) | | 0.161 | 0.183 | 0.193 | 0.179 | 0.0164 | 9.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 4 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.206 | 0.201 | 0.206 | 0.204 | 0.0029 | 1.41 |
| | Stnd Conc (mg/L) | | 0.206 | 0.201 | 0.206 | 0.204 | 0.0029 | 1.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 5 | BlnkCorr Signal | | 0.005 | 0.006 | 0.007 | 0.006 | 0.0010 | 16.67 |
| | sample conc (mg/L) | | 0.112 | 0.123 | 0.147 | 0.127 | 0.0179 | 14.06 |
| | Stnd Conc (mg/L) | | 0.112 | 0.123 | 0.147 | 0.127 | 0.0179 | 14.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 6 | BlnkCorr Signal | | 0.006 | 0.006 | 0.007 | 0.006 | 0.0006 | 9.12 |
| | sample conc (mg/L) | | 0.144 | 0.127 | 0.148 | 0.140 | 0.0112 | 7.98 |
| | Stnd Conc (mg/L) | | 0.144 | 0.127 | 0.148 | 0.140 | 0.0112 | 7.98 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 0 | BlnkCorr Signal | | 0.009 | 0.008 | 0.008 | 0.008 | 0.0006 | 6.93 |
| | sample conc (mg/L) | | 0.193 | 0.190 | 0.190 | 0.191 | 0.0017 | 0.91 |
| | Stnd Conc (mg/L) | | 0.193 | 0.190 | 0.190 | 0.191 | 0.0017 | 0.91 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 2.5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.209 | 0.202 | 0.191 | 0.201 | 0.0091 | 4.52 |
| | Stnd Conc (mg/L) | | 0.209 | 0.202 | 0.191 | 0.201 | 0.0091 | 4.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.200 | 0.213 | 0.211 | 0.208 | 0.0070 | 3.37 |
| | Stnd Conc (mg/L) | | 0.200 | 0.213 | 0.211 | 0.208 | 0.0070 | 3.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 7.5 | BlnkCorr Signal | | 0.008 | 0.006 | 0.006 | 0.007 | 0.0012 | 17.32 |
| | sample conc (mg/L) | | 0.230 | 0.206 | 0.159 | 0.198 | 0.0361 | 18.21 |
| | Stnd Conc (mg/L) | | 0.230 | 0.206 | 0.159 | 0.198 | 0.0361 | 18.21 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 0 | BlnkCorr Signal | | 0.008 | 0.006 | 0.006 | 0.007 | 0.0012 | 17.32 |
| | sample conc (mg/L) | | 0.171 | 0.130 | 0.141 | 0.147 | 0.0212 | 14.40 |
| | Stnd Conc (mg/L) | | 0.171 | 0.130 | 0.141 | 0.147 | 0.0212 | 14.40 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 3.5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.194 | 0.203 | 0.206 | 0.201 | 0.0062 | 3.11 |
| | Stnd Conc (mg/L) | | 0.194 | 0.203 | 0.206 | 0.201 | 0.0062 | 3.11 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 7 | BlnkCorr Signal | | 0.010 | 0.007 | 0.004 | 0.007 | 0.0030 | 42.86 |
| | sample conc (mg/L) | | 0.215 | 0.157 | 0.100 | 0.157 | 0.0575 | 36.55 |
| | Stnd Conc (mg/L) | | 0.215 | 0.157 | 0.100 | 0.157 | 0.0575 | 36.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 0 | BlnkCorr Signal | | 0.008 | 0.008 | 0.005 | 0.007 | 0.0017 | 24.74 |
| | sample conc (mg/L) | | 0.188 | 0.169 | 0.122 | 0.160 | 0.0340 | 21.28 |
| | Stnd Conc (mg/L) | | 0.188 | 0.169 | 0.122 | 0.160 | 0.0340 | 21.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.202 | 0.204 | 0.199 | 0.202 | 0.0025 | 1.25 |
| | Stnd Conc (mg/L) | | 0.202 | 0.204 | 0.199 | 0.202 | 0.0025 | 1.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 | BlnkCorr Signal | | 0.010 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.19 |
| | sample conc (mg/L) | | 0.220 | 0.213 | 0.199 | 0.211 | 0.0107 | 5.08 |
| | Stnd Conc (mg/L) | | 0.220 | 0.213 | 0.199 | 0.211 | 0.0107 | 5.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.008 | 0.008 | 0.009 | 0.008 | 0.0006 | 6.93 |
| | sample conc (mg/L) | | 0.172 | 0.184 | 0.199 | 0.185 | 0.0135 | 7.31 |
| | Stnd Conc (mg/L) | | 0.172 | 0.184 | 0.199 | 0.185 | 0.0135 | 7.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RR | BlnkCorr Signal | | 0.010 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.19 |
| | sample conc (mg/L) | | 0.215 | 0.205 | 0.201 | 0.207 | 0.0072 | 3.48 |
| | Stnd Conc (mg/L) | | 0.215 | 0.205 | 0.201 | 0.207 | 0.0072 | 3.48 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RRR | BlnkCorr Signal | | 0.010 | 0.010 | 0.009 | 0.010 | 0.0006 | 5.97 |
| | sample conc (mg/L) | | 0.220 | 0.216 | 0.209 | 0.215 | 0.0056 | 2.59 |
| | Stnd Conc (mg/L) | | 0.220 | 0.216 | 0.209 | 0.215 | 0.0056 | 2.59 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day5** hr 0 | BlnkCorr Signal | | 0.009 | 0.009 | 0.008 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 0.207 | 0.190 | 0.173 | 0.190 | 0.0170 | 8.95 |
| | Stnd Conc (mg/L) | | 0.207 | 0.190 | 0.173 | 0.190 | 0.0170 | 8.95 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day5** hr 7 | BlnkCorr Signal | | 0.009 | 0.010 | 0.009 | 0.009 | 0.0006 | 6.19 |
| | sample conc (mg/L) | | 0.212 | 0.216 | 0.212 | 0.213 | 0.0023 | 1.08 |
| | Stnd Conc (mg/L) | | 0.212 | 0.216 | 0.212 | 0.213 | 0.0023 | 1.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.009 | 0.010 | 0.010 | 0.010 | 0.0006 | 5.97 |
| | sample conc (mg/L) | | 0.211 | 0.223 | 0.240 | 0.225 | 0.0146 | 6.49 |
| | Stnd Conc (mg/L) | | 0.211 | 0.223 | 0.240 | 0.225 | 0.0146 | 6.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.009 | 0.007 | 0.005 | 0.007 | 0.0020 | 28.57 |
| | sample conc (mg/L) | | 0.189 | 0.154 | 0.105 | 0.149 | 0.0422 | 28.25 |
| | Stnd Conc (mg/L) | | 0.189 | 0.154 | 0.105 | 0.149 | 0.0422 | 28.25 |

**23.3% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 | BlnkCorr Signal | | 0.043 | 0.043 | 0.040 | 0.042 | 0.0017 | 4.12 |
| | sample conc (mg/L) | | 2.719 | 2.721 | 2.550 | 2.663 | 0.0982 | 3.69 |
| | Stnd Conc (mg/L) | | 2.719 | 2.721 | 2.550 | 2.663 | 0.0982 | 3.69 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 R | BlnkCorr Signal | | 0.043 | 0.042 | 0.043 | 0.043 | 0.0006 | 1.35 |
| | sample conc (mg/L) | | 2.734 | 2.690 | 2.771 | 2.732 | 0.0406 | 1.48 |
| | Stnd Conc (mg/L) | | 2.734 | 2.690 | 2.771 | 2.732 | 0.0406 | 1.48 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 2 | BlnkCorr Signal | | 0.074 | 0.073 | 0.073 | 0.073 | 0.0006 | 0.79 |
| | sample conc (mg/L) | | 4.684 | 4.590 | 4.618 | 4.631 | 0.0483 | 1.04 |
| | Stnd Conc (mg/L) | | 4.684 | 4.590 | 4.618 | 4.631 | 0.0483 | 1.04 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 3 | BlnkCorr Signal | | 0.275 | 0.295 | 0.293 | 0.288 | 0.0110 | 3.83 |
| | sample conc (mg/L) | | 16.25 | 17.36 | 17.25 | 16.95 | 0.6116 | 3.61 |
| | Stnd Conc (mg/L) | | 16.25 | 17.36 | 17.25 | 16.95 | 0.6116 | 3.61 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 4 | BlnkCorr Signal | | 0.320 | 0.317 | 0.318 | 0.318 | 0.0015 | 0.48 |
| | sample conc (mg/L) | | 18.69 | 18.53 | 18.56 | 18.59 | 0.0850 | 0.46 |
| | Stnd Conc (mg/L) | | 18.69 | 18.53 | 18.56 | 18.59 | 0.0850 | 0.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 5 | BlnkCorr Signal | | 0.317 | 0.319 | 0.318 | 0.318 | 0.0010 | 0.31 |
| | sample conc (mg/L) | | 18.53 | 18.60 | 18.57 | 18.57 | 0.0351 | 0.19 |
| | Stnd Conc (mg/L) | | 18.53 | 18.60 | 18.57 | 18.57 | 0.0351 | 0.19 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 6 | BlnkCorr Signal | | 0.250 | 0.289 | 0.318 | 0.286 | 0.0341 | 11.94 |
| | sample conc (mg/L) | | 18.94 | 17.00 | 18.54 | 18.16 | 1.0243 | 5.64 |
| | Stnd Conc (mg/L) | | 18.94 | 17.00 | 18.54 | 18.16 | 1.0243 | 5.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 0 | BlnkCorr Signal | | 0.340 | 0.341 | 0.346 | 0.342 | 0.0032 | 0.94 |
| | sample conc (mg/L) | | 19.72 | 19.78 | 20.01 | 19.84 | 0.1531 | 0.77 |
| | Stnd Conc (mg/L) | | 19.72 | 19.78 | 20.01 | 19.84 | 0.1531 | 0.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 2.5 | BlnkCorr Signal | | 0.340 | 0.340 | 0.339 | 0.340 | 0.0006 | 0.17 |
| | sample conc (mg/L) | | 19.72 | 19.69 | 19.65 | 19.69 | 0.0351 | 0.18 |
| | Stnd Conc (mg/L) | | 19.72 | 19.69 | 19.65 | 19.69 | 0.0351 | 0.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 5 | BlnkCorr Signal | | 0.313 | 0.324 | 0.352 | 0.330 | 0.0201 | 6.10 |
| | sample conc (mg/L) | | 18.28 | 18.88 | 20.30 | 19.15 | 1.0374 | 5.42 |
| | Stnd Conc (mg/L) | | 18.28 | 18.88 | 20.30 | 19.15 | 1.0374 | 5.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 7.5 | BlnkCorr Signal | | 0.342 | 0.342 | 0.342 | 0.342 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 19.80 | 19.81 | 19.82 | 19.81 | 0.0100 | 0.05 |
| | Stnd Conc (mg/L) | | 19.80 | 19.81 | 19.82 | 19.81 | 0.0100 | 0.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 0 | BlnkCorr Signal | | 0.338 | 0.335 | 0.333 | 0.335 | 0.0025 | 0.75 |
| | sample conc (mg/L) | | 19.61 | 19.44 | 19.34 | 19.46 | 0.1365 | 0.70 |
| | Stnd Conc (mg/L) | | 19.61 | 19.44 | 19.34 | 19.46 | 0.1365 | 0.70 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 3.5 | BlnkCorr Signal | | 0.354 | 0.358 | 0.356 | 0.356 | 0.0020 | 0.56 |
| | sample conc (mg/L) | | 20.42 | 20.62 | 20.53 | 20.52 | 0.1002 | 0.49 |
| | Stnd Conc (mg/L) | | 20.42 | 20.62 | 20.53 | 20.52 | 0.1002 | 0.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 7 | BlnkCorr Signal | | 0.367 | 0.362 | 0.460 | 0.396 | 0.0552 | 13.93 |
| | sample conc (mg/L) | | 21.09 | 20.84 | 20.02 | 20.65 | 0.5597 | 2.71 |
| | Stnd Conc (mg/L) | | 21.09 | 20.84 | 20.02 | 20.65 | 0.5597 | 2.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 0 | BlnkCorr Signal | | 0.369 | 0.369 | 0.369 | 0.369 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 21.20 | 21.17 | 21.21 | 21.19 | 0.0208 | 0.10 |
| | Stnd Conc (mg/L) | | 21.20 | 21.17 | 21.21 | 21.19 | 0.0208 | 0.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 7 | BlnkCorr Signal | | 0.371 | 0.371 | 0.372 | 0.371 | 0.0006 | 0.16 |
| | sample conc (mg/L) | | 21.29 | 21.29 | 21.33 | 21.30 | 0.0231 | 0.11 |
| | Stnd Conc (mg/L) | | 21.29 | 21.29 | 21.33 | 21.30 | 0.0231 | 0.11 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 | BlnkCorr Signal | | 0.323 | 0.323 | 0.323 | 0.323 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 18.85 | 18.82 | 18.82 | 18.83 | 0.0173 | 0.09 |
| | Stnd Conc (mg/L) | | 18.85 | 18.82 | 18.82 | 18.83 | 0.0173 | 0.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.312 | 0.313 | 0.315 | 0.313 | 0.0015 | 0.49 |
| | sample conc (mg/L) | | 18.24 | 18.90 | 18.40 | 18.51 | 0.3443 | 1.86 |
| | Stnd Conc (mg/L) | | 18.24 | 18.90 | 18.40 | 18.51 | 0.3443 | 1.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day5** hr 0 | BlnkCorr Signal | | 0.337 | 0.332 | 0.331 | 0.333 | 0.0032 | 0.96 |
| | sample conc (mg/L) | | 19.86 | 19.30 | 19.26 | 19.47 | 0.3355 | 1.72 |
| | Stnd Conc (mg/L) | | 19.86 | 19.30 | 19.26 | 19.47 | 0.3355 | 1.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day5** hr 7 | BlnkCorr Signal | | 0.354 | 0.352 | 0.351 | 0.352 | 0.0015 | 0.43 |
| | sample conc (mg/L) | | 20.45 | 20.30 | 20.26 | 20.34 | 0.1002 | 0.49 |
| | Stnd Conc (mg/L) | | 20.45 | 20.30 | 20.26 | 20.34 | 0.1002 | 0.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.370 | 0.363 | 0.364 | 0.366 | 0.0038 | 1.04 |
| | sample conc (mg/L) | | 21.27 | 20.88 | 20.95 | 21.03 | 0.2079 | 0.99 |
| | Stnd Conc (mg/L) | | 21.27 | 20.88 | 20.95 | 21.03 | 0.2079 | 0.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.373 | 0.374 | 0.373 | 0.373 | 0.0006 | 0.15 |
| | sample conc (mg/L) | | 21.40 | 21.45 | 21.42 | 21.42 | 0.0252 | 0.12 |
| | Stnd Conc (mg/L) | | 21.40 | 21.45 | 21.42 | 21.42 | 0.0252 | 0.12 |

### 7.4.3. Appendix 4c - Chromium Temperature raw data

**5% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 19.50 |
| | 2 | 19.50 |
| | 3 | 18.50 |
| | 4 | 18.50 |
| | 5 | 18.75 |
| | 6 | 19.00 |
| 2 | 24 | 19.00 |
| | 26.5 | 19.75 |
| | 29 | 20.25 |
| | 31.5 | 20.75 |
| 3 | 48 | 20.00 |
| | 51.5 | 20.00 |
| | 55 | 19.75 |
| 4 | 72 | 21.00 |
| | 79 | 21.75 |
| | **84.5** | 23.00 |
| 5 | 96.5 | 21.25 |
| | 103.5 | 21.25 |
| 8 | **168** | 20.00 |

**14.15% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 20.50 |
| | 2 | 19.75 |
| | 3 | 18.50 |
| | 4 | 18.50 |
| | 5 | 18.50 |
| | 6 | 18.75 |
| 2 | 24 | 18.75 |
| | 26.5 | 19.50 |
| | 29 | 20.00 |
| | 31.5 | 20.25 |
| 3 | 48 | 19.50 |
| | 51.5 | 20.00 |
| | 55 | 19.25 |
| 4 | 72 | 20.50 |
| | 79 | 21.50 |
| | **84.5** | 22.75 |
| 5 | 96.5 | 21.00 |
| | 103.5 | 21.00 |
| 8 | **168** | 20.00 |

**23.3% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 22.00 |
| | 2 | 22.50 |
| | 3 | 22.00 |
| | 4 | 19.00 |
| | 5 | 19.00 |
| | 6 | 19.00 |
| 2 | 24 | 19.00 |
| | 26.5 | 20.00 |
| | 29 | 20.50 |
| | 31.5 | 20.50 |

| Day | Hours | Temperature (°C) |
|---|---|---|
| 3 | 48 | 20.00 |
| | 51.5 | 20.25 |
| | 55 | 20.00 |
| 4 | 72 | 21.00 |
| | 79 | 22.00 |
| | **84.5** | 23.50 |
| 5 | 96.5 | 21.50 |
| | 103.5 | 22.00 |
| 8 | **168** | 21.00 |

### 7.5.1. Appendix 5a - Cobalt Calibration graph raw data

range: 3 - 9 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 1.229 | 1.229 | 0.00058 | 0.05 |
| | 1.228 | | | |
| | 1.229 | | | |
| 3 | 0.080 | 0.080 | 0.00000 | 0.00 |
| | 0.080 | | | |
| | 0.080 | | | |
| 5 | 0.120 | 0.120 | 0.00000 | 0.00 |
| | 0.120 | | | |
| | 0.120 | | | |
| 7 | 0.167 | 0.165 | 0.00208 | 1.26 |
| | 0.166 | | | |
| | 0.163 | | | |
| 9 | 0.209 | 0.210 | 0.00153 | 0.73 |
| | 0.210 | | | |
| | 0.212 | | | |

range: 10 - 150 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 1.272 | 1.272 | 0.00058 | 0.05 |
| | 1.273 | | | |
| | 1.272 | | | |
| 10 | 0.267 | 0.268 | 0.00115 | 0.43 |
| | 0.269 | | | |
| | 0.269 | | | |
| 50 | 0.913 | 0.911 | 0.00200 | 0.22 |
| | 0.909 | | | |
| | 0.911 | | | |
| 100 | 1.108 | 1.100 | 0.00681 | 0.62 |
| | 1.098 | | | |
| | 1.095 | | | |
| 150 | 1.145 | 1.142 | 0.00265 | 0.23 |
| | 1.140 | | | |
| | 1.141 | | | |

### 7.5.2. Appendix 5b - Cobalt AAS raw data

**<u>5% aqua regia sample raw data</u>**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 | BlnkCorr Signal | | 0.008 | 0.007 | 0.007 | 0.007 | 0.0006 | 7.87 |
| | sample conc (mg/L) | | 0.293 | 0.268 | 0.259 | 0.273 | 0.0176 | 6.44 |
| | Stnd Conc (mg/L) | | 0.293 | 0.268 | 0.259 | 0.273 | 0.0176 | 6.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 R | BlnkCorr Signal | | 0.020 | 0.017 | 0.017 | 0.018 | 0.0017 | 9.62 |
| | sample conc (mg/L) | | 0.718 | 0.615 | 0.607 | 0.647 | 0.0619 | 9.57 |
| | Stnd Conc (mg/L) | | 0.718 | 0.615 | 0.607 | 0.647 | 0.0619 | 9.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 2 | BlnkCorr Signal | | 0.009 | 0.011 | 0.010 | 0.010 | 0.0010 | 10.00 |
| | sample conc (mg/L) | | 0.333 | 0.414 | 0.358 | 0.368 | 0.0415 | 11.26 |
| | Stnd Conc (mg/L) | | 0.333 | 0.414 | 0.358 | 0.368 | 0.0415 | 11.26 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 3 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.396 | 0.415 | 0.385 | 0.399 | 0.0152 | 3.81 |
| | Stnd Conc (mg/L) | | 0.369 | 0.415 | 0.385 | 0.390 | 0.0234 | 5.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 4 | BlnkCorr Signal | | 0.012 | 0.013 | 0.014 | 0.013 | 0.0010 | 7.69 |
| | sample conc (mg/L) | | 0.436 | 0.460 | 0.495 | 0.464 | 0.0297 | 6.40 |
| | Stnd Conc (mg/L) | | 0.436 | 0.460 | 0.495 | 0.464 | 0.0297 | 6.40 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 5 | BlnkCorr Signal | | 0.016 | 0.015 | 0.014 | 0.015 | 0.0010 | 6.67 |
| | sample conc (mg/L) | | 0.584 | 0.545 | 0.516 | 0.548 | 0.0341 | 6.22 |
| | Stnd Conc (mg/L) | | 0.584 | 0.545 | 0.516 | 0.548 | 0.0341 | 6.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 6 | BlnkCorr Signal | | 0.035 | 0.029 | 0.024 | 0.029 | 0.0055 | 18.78 |
| | sample conc (mg/L) | | 1.307 | 1.076 | 0.868 | 1.084 | 0.2196 | 20.26 |
| | Stnd Conc (mg/L) | | 1.307 | 1.076 | 0.868 | 1.084 | 0.2196 | 20.26 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 0 | BlnkCorr Signal | | 0.039 | 0.039 | 0.039 | 0.039 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 1.444 | 1.436 | 1.440 | 1.440 | 0.0040 | 0.28 |
| | Stnd Conc (mg/L) | | 1.444 | 1.436 | 1.440 | 1.440 | 0.0040 | 0.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 2.5 | BlnkCorr Signal | | 0.043 | 0.043 | 0.043 | 0.043 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 1.601 | 1.593 | 1.583 | 1.592 | 0.0090 | 0.57 |
| | Stnd Conc (mg/L) | | 1.601 | 1.593 | 1.583 | 1.592 | 0.0090 | 0.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 5 | BlnkCorr Signal | | 0.046 | 0.046 | 0.045 | 0.046 | 0.0006 | 1.26 |
| | sample conc (mg/L) | | 1.723 | 1.711 | 1.677 | 1.704 | 0.0239 | 1.40 |
| | Stnd Conc (mg/L) | | 1.723 | 1.711 | 1.677 | 1.704 | 0.0239 | 1.40 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 7.5 | BlnkCorr Signal | | 0.053 | 0.049 | 0.046 | 0.049 | 0.0035 | 7.12 |
| | sample conc (mg/L) | | 2.006 | 1.817 | 1.704 | 1.842 | 0.1526 | 8.28 |
| | Stnd Conc (mg/L) | | 2.006 | 1.817 | 1.704 | 1.842 | 0.1526 | 8.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 0 | BlnkCorr Signal | | 0.064 | 0.064 | 0.062 | 0.063 | 0.0012 | 1.82 |
| | sample conc (mg/L) | | 2.408 | 2.408 | 2.358 | 2.391 | 0.0289 | 1.21 |
| | Stnd Conc (mg/L) | | 2.408 | 2.408 | 2.358 | 2.391 | 0.0289 | 1.21 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 3.5 | BlnkCorr Signal | | 0.067 | 0.067 | 0.064 | 0.066 | 0.0017 | 2.62 |
| | sample conc (mg/L) | | 2.546 | 2.550 | 2.428 | 2.508 | 0.0693 | 2.76 |
| | Stnd Conc (mg/L) | | 2.546 | 2.550 | 2.428 | 2.508 | 0.0693 | 2.76 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 7 | BlnkCorr Signal | | 0.066 | 0.066 | 0.067 | 0.066 | 0.0006 | 0.87 |
| | sample conc (mg/L) | | 2.494 | 2.518 | 2.530 | 2.514 | 0.0183 | 0.73 |
| | Stnd Conc (mg/L) | | 2.494 | 2.518 | 2.530 | 2.514 | 0.0183 | 0.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 0 | BlnkCorr Signal | | 0.082 | 0.082 | 0.081 | 0.082 | 0.0006 | 0.71 |
| | sample conc (mg/L) | | 3.160 | 3.189 | 3.131 | 3.160 | 0.0290 | 0.92 |
| | Stnd Conc (mg/L) | | 3.160 | 3.189 | 3.131 | 3.160 | 0.0290 | 0.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 7 | BlnkCorr Signal | | 0.083 | 0.084 | 0.083 | 0.083 | 0.0006 | 0.69 |
| | sample conc (mg/L) | | 3.183 | 3.258 | 3.191 | 3.211 | 0.0412 | 1.28 |
| | Stnd Conc (mg/L) | | 3.183 | 3.258 | 3.191 | 3.211 | 0.0412 | 1.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 | BlnkCorr Signal | | 0.082 | 0.081 | 0.081 | 0.081 | 0.0006 | 0.71 |
| | sample conc (mg/L) | | 3.179 | 3.127 | 3.131 | 3.146 | 0.0289 | 0.92 |
| | Stnd Conc (mg/L) | | 3.179 | 3.127 | 3.131 | 3.146 | 0.0289 | 0.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.083 | 0.083 | 0.083 | 0.083 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 3.190 | 3.196 | 3.197 | 3.194 | 0.0038 | 0.12 |
| | Stnd Conc (mg/L) | | 3.190 | 3.196 | 3.197 | 3.194 | 0.0038 | 0.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 0 | BlnkCorr Signal | | 0.138 | 0.145 | 0.145 | 0.143 | 0.0040 | 2.83 |
| | sample conc (mg/L) | | 5.618 | 5.942 | 5.927 | 5.829 | 0.1829 | 3.14 |
| | Stnd Conc (mg/L) | | 5.618 | 5.942 | 5.927 | 5.829 | 0.1829 | 3.14 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 7 | BlnkCorr Signal | | 0.142 | 0.142 | 0.139 | 0.141 | 0.0017 | 1.23 |
| | sample conc (mg/L) | | 5.793 | 5.777 | 5.669 | 5.746 | 0.0674 | 1.17 |
| | Stnd Conc (mg/L) | | 5.793 | 5.777 | 5.669 | 5.746 | 0.0674 | 1.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.147 | 0.145 | 0.144 | 0.145 | 0.0015 | 1.05 |
| | sample conc (mg/L) | | 6.016 | 5.952 | 5.915 | 5.961 | 0.0511 | 0.86 |
| | Stnd Conc (mg/L) | | 6.016 | 5.952 | 5.915 | 5.961 | 0.0511 | 0.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.149 | 0.142 | 0.143 | 0.145 | 0.0038 | 2.62 |
| | sample conc (mg/L) | | 6.020 | 5.809 | 5.847 | 5.892 | 0.1125 | 1.91 |
| | Stnd Conc (mg/L) | | 6.020 | 5.809 | 5.847 | 5.892 | 0.1125 | 1.91 |

**<u>14.15% aqua regia sample raw data</u>**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 | BlnkCorr Signal | | 0.014 | 0.015 | 0.014 | 0.014 | 0.0006 | 4.03 |
| | sample conc (mg/L) | | 0.508 | 0.543 | 0.525 | 0.525 | 0.0175 | 3.33 |
| | Stnd Conc (mg/L) | | 0.508 | 0.543 | 0.525 | 0.525 | 0.0175 | 3.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 R | BlnkCorr Signal | | 0.015 | 0.014 | 0.015 | 0.015 | 0.0006 | 3.94 |
| | sample conc (mg/L) | | 0.540 | 0.525 | 0.556 | 0.540 | 0.0155 | 2.87 |
| | Stnd Conc (mg/L) | | 0.540 | 0.525 | 0.556 | 0.540 | 0.0155 | 2.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 2 | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 0.621 | 0.617 | 0.618 | 0.619 | 0.0021 | 0.34 |
| | Stnd Conc (mg/L) | | 0.621 | 0.617 | 0.618 | 0.619 | 0.0021 | 0.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 3 | BlnkCorr Signal | | 0.018 | 0.019 | 0.021 | 0.019 | 0.0015 | 7.90 |
| | sample conc (mg/L) | | 0.639 | 0.706 | 0.755 | 0.700 | 0.0582 | 8.32 |
| | Stnd Conc (mg/L) | | 0.639 | 0.706 | 0.755 | 0.700 | 0.0582 | 8.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 4 | BlnkCorr Signal | | 0.040 | 0.035 | 0.030 | 0.035 | 0.0050 | 14.29 |
| | sample conc (mg/L) | | 1.479 | 1.283 | 1.089 | 1.284 | 0.1950 | 15.19 |
| | Stnd Conc (mg/L) | | 1.479 | 1.283 | 1.089 | 1.284 | 0.1950 | 15.19 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 5 | BlnkCorr Signal | | 0.038 | 0.038 | 0.038 | 0.038 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 1.419 | 1.403 | 1.406 | 1.409 | 0.0085 | 0.60 |
| | Stnd Conc (mg/L) | | 1.419 | 1.403 | 1.406 | 1.409 | 0.0085 | 0.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 6 | BlnkCorr Signal | | 0.026 | 0.026 | 0.028 | 0.027 | 0.0012 | 4.33 |
| | sample conc (mg/L) | | 0.969 | 0.964 | 1.025 | 0.986 | 0.0339 | 3.43 |
| | Stnd Conc (mg/L) | | 0.969 | 0.964 | 1.025 | 0.986 | 0.0339 | 3.43 |
| 14.15% **Day1** hr 6 rerun | BlnkCorr Signal | | 0.026 | 0.025 | 0.031 | 0.027 | 0.0032 | 11.76 |
| | sample conc (mg/L) | | 0.950 | 0.908 | 1.133 | 0.997 | 0.1196 | 12.00 |
| | Stnd Conc (mg/L) | | 0.950 | 0.908 | 1.133 | 0.997 | 0.1196 | 12.00 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 0 | BlnkCorr Signal | | 0.058 | 0.057 | 0.058 | 0.058 | 0.0006 | 1.00 |
| | sample conc (mg/L) | | 2.168 | 2.166 | 2.175 | 2.170 | 0.0047 | 0.22 |
| | Stnd Conc (mg/L) | | 2.168 | 2.166 | 2.175 | 2.170 | 0.0047 | 0.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 2.5 | BlnkCorr Signal | | 0.060 | 0.060 | 0.059 | 0.060 | 0.0006 | 0.97 |
| | sample conc (mg/L) | | 2.274 | 2.256 | 2.233 | 2.254 | 0.0206 | 0.91 |
| | Stnd Conc (mg/L) | | 2.274 | 2.256 | 2.233 | 2.254 | 0.0206 | 0.91 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 5 | BlnkCorr Signal | | 0.060 | 0.060 | 0.059 | 0.060 | 0.0006 | 0.97 |
| | sample conc (mg/L) | | 2.279 | 2.276 | 2.214 | 2.256 | 0.0367 | 1.63 |
| | Stnd Conc (mg/L) | | 2.279 | 2.276 | 2.214 | 2.256 | 0.0367 | 1.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 7.5 | BlnkCorr Signal | | 0.064 | 0.063 | 0.063 | 0.063 | 0.0006 | 0.91 |
| | sample conc (mg/L) | | 2.439 | 2.404 | 2.397 | 2.413 | 0.0225 | 0.93 |
| | Stnd Conc (mg/L) | | 2.439 | 2.404 | 2.397 | 2.413 | 0.0225 | 0.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 0 | BlnkCorr Signal | | 0.093 | 0.096 | 0.096 | 0.095 | 0.0017 | 1.82 |
| | sample conc (mg/L) | | 3.615 | 3.761 | 3.742 | 3.706 | 0.0794 | 2.14 |
| | Stnd Conc (mg/L) | | 3.615 | 3.761 | 3.742 | 3.706 | 0.0794 | 2.14 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 3.5 | BlnkCorr Signal | | 0.096 | 0.099 | 0.097 | 0.097 | 0.0015 | 1.57 |
| | sample conc (mg/L) | | 3.759 | 3.881 | 3.798 | 3.813 | 0.0623 | 1.63 |
| | Stnd Conc (mg/L) | | 3.759 | 3.881 | 3.798 | 3.813 | 0.0623 | 1.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 7 | BlnkCorr Signal | | 0.104 | 0.105 | 0.103 | 0.104 | 0.0010 | 0.96 |
| | sample conc (mg/L) | | 4.082 | 4.142 | 4.058 | 4.094 | 0.0433 | 1.06 |
| | Stnd Conc (mg/L) | | 4.080 | 4.142 | 4.058 | 4.093 | 0.0436 | 1.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 0 | BlnkCorr Signal | | 0.130 | 0.131 | 0.131 | 0.131 | 0.0006 | 0.44 |
| | sample conc (mg/L) | | 5.260 | 5.278 | 5.311 | 5.283 | 0.0259 | 0.49 |
| | Stnd Conc (mg/L) | | 5.260 | 5.278 | 5.311 | 5.283 | 0.0259 | 0.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 | BlnkCorr Signal | | 0.121 | 0.123 | 0.124 | 0.123 | 0.0015 | 1.25 |
| | sample conc (mg/L) | | 4.845 | 4.919 | 4.974 | 4.913 | 0.0647 | 1.32 |
| | Stnd Conc (mg/L) | | 4.845 | 4.919 | 4.974 | 4.913 | 0.0647 | 1.32 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 rerun | BlnkCorr Signal | | 0.120 | 0.124 | 0.122 | 0.122 | 0.0020 | 1.64 |
| | sample conc (mg/L) | | 4.798 | 4.954 | 4.887 | 4.880 | 0.0783 | 1.60 |
| | Stnd Conc (mg/L) | | 4.798 | 4.954 | 4.887 | 4.880 | 0.0783 | 1.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 | BlnkCorr Signal | | 0.124 | 0.124 | 0.125 | 0.124 | 0.0006 | 0.46 |
| | sample conc (mg/L) | | 4.984 | 4.967 | 5.016 | 4.989 | 0.0249 | 0.50 |
| | Stnd Conc (mg/L) | | 4.984 | 4.967 | 5.016 | 4.989 | 0.0249 | 0.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.126 | 0.124 | 0.126 | 0.125 | 0.0012 | 0.92 |
| | sample conc (mg/L) | | 5.068 | 4.969 | 5.054 | 5.030 | 0.0536 | 1.07 |
| | Stnd Conc (mg/L) | | 5.068 | 4.969 | 5.054 | 5.030 | 0.0536 | 1.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RR | BlnkCorr Signal | | 0.124 | 0.125 | 0.126 | 0.125 | 0.0010 | 0.80 |
| | sample conc (mg/L) | | 4.998 | 5.037 | 5.051 | 5.029 | 0.0275 | 0.55 |
| | Stnd Conc (mg/L) | | 4.998 | 5.037 | 5.051 | 5.029 | 0.0275 | 0.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RRR | BlnkCorr Signal | | 0.126 | 0.127 | 0.124 | 0.126 | 0.0015 | 1.22 |
| | sample conc (mg/L) | | 5.072 | 5.113 | 4.998 | 5.061 | 0.0583 | 1.15 |
| | Stnd Conc (mg/L) | | 5.072 | 5.113 | 4.998 | 5.061 | 0.0583 | 1.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 0 | BlnkCorr Signal | | 0.240 | 0.254 | 0.268 | 0.254 | 0.0140 | 5.51 |
| | sample conc (mg/L) | | 8.888 | 9.415 | 9.969 | 9.424 | 0.5406 | 5.74 |
| | Stnd Conc (mg/L) | | 8.888 | 9.415 | 9.969 | 9.424 | 0.5406 | 5.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 7 | BlnkCorr Signal | | 0.247 | 0.255 | 0.274 | 0.259 | 0.0139 | 5.36 |
| | sample conc (mg/L) | | 9.154 | 9.461 | 10.22 | 9.612 | 0.5487 | 5.71 |
| | Stnd Conc (mg/L) | | 9.154 | 9.461 | 10.22 | 9.612 | 0.5487 | 5.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.283 | 0.283 | 0.285 | 0.284 | 0.0012 | 0.41 |
| | sample conc (mg/L) | | 10.57 | 10.55 | 10.64 | 10.59 | 0.0473 | 0.45 |
| | Stnd Conc (mg/L) | | 10.57 | 10.55 | 10.64 | 10.59 | 0.0473 | 0.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.283 | 0.266 | 0.261 | 0.270 | 0.0115 | 4.27 |
| | sample conc (mg/L) | | 10.57 | 9.892 | 9.681 | 10.05 | 0.4645 | 4.62 |
| | Stnd Conc (mg/L) | | 10.57 | 9.892 | 9.681 | 10.05 | 0.4645 | 4.62 |

## 23.3% aqua regia sample raw data

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 | BlnkCorr Signal | | 0.176 | 0.176 | 0.176 | 0.176 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 6.429 | 6.422 | 6.442 | 6.431 | 0.0101 | 0.16 |
| | Stnd Conc (mg/L) | | 6.429 | 6.422 | 6.442 | 6.431 | 0.0101 | 0.16 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 R | BlnkCorr Signal | | 0.177 | 0.177 | 0.177 | 0.177 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 6.455 | 6.820 | 6.468 | 6.581 | 0.2071 | 3.15 |
| | Stnd Conc (mg/L) | | 6.455 | 6.820 | 6.468 | 6.581 | 0.2071 | 3.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 2 | BlnkCorr Signal | | 0.323 | 0.322 | 0.322 | 0.322 | 0.0006 | 0.18 |
| | sample conc (mg/L) | | 12.16 | 12.13 | 12.12 | 12.14 | 0.0208 | 0.17 |
| | Stnd Conc (mg/L) | | 12.16 | 12.13 | 12.12 | 12.14 | 0.0208 | 0.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 3 | BlnkCorr Signal | | 0.376 | 0.377 | 0.376 | 0.376 | 0.0006 | 0.15 |
| | sample conc (mg/L) | | 14.35 | 14.41 | 14.36 | 14.37 | 0.0321 | 0.22 |
| | Stnd Conc (mg/L) | | 14.35 | 14.41 | 14.36 | 14.37 | 0.0321 | 0.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 4 | BlnkCorr Signal | | 0.476 | 0.459 | 0.480 | 0.472 | 0.0112 | 2.36 |
| | sample conc (mg/L) | | 18.73 | 17.98 | 18.91 | 18.54 | 0.4933 | 2.66 |
| | Stnd Conc (mg/L) | | 18.73 | 17.98 | 18.91 | 18.54 | 0.4933 | 2.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 5 | BlnkCorr Signal | | 0.583 | 0.590 | 0.608 | 0.594 | 0.0129 | 2.17 |
| | sample conc (mg/L) | | 29.43 | 29.24 | 29.40 | 29.36 | 0.1021 | 0.35 |
| | Stnd Conc (mg/L) | | 29.43 | 29.24 | 29.40 | 29.36 | 0.1021 | 0.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 6 | BlnkCorr Signal | | 0.679 | 0.676 | 0.679 | 0.678 | 0.0017 | 0.26 |
| | sample conc (mg/L) | | 29.43 | 29.24 | 29.40 | 29.36 | 0.1021 | 0.35 |
| | Stnd Conc (mg/L) | | 29.43 | 29.24 | 29.40 | 29.36 | 0.1021 | 0.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 0 | BlnkCorr Signal | | 0.924 | 0.922 | 0.914 | 0.920 | 0.0053 | 0.58 |
| | sample conc (mg/L) | | 52.25 | 51.96 | 50.75 | 51.65 | 0.7956 | 1.54 |
| | Stnd Conc (mg/L) | | 52.25 | 51.96 | 50.75 | 51.65 | 0.7956 | 1.54 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 2.5 | BlnkCorr Signal | | 0.929 | 0.929 | 0.934 | 0.931 | 0.0029 | 0.31 |
| | sample conc (mg/L) | | 53.03 | 53.01 | 53.92 | 53.32 | 0.5197 | 0.97 |
| | Stnd Conc (mg/L) | | 53.03 | 53.01 | 53.92 | 53.32 | 0.5197 | 0.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 5 | BlnkCorr Signal | | 0.756 | 0.787 | 0.833 | 0.792 | 0.0387 | 4.89 |
| | sample conc (mg/L) | | 34.58 | 36.99 | 41.15 | 37.57 | 3.3236 | 8.85 |
| | Stnd Conc (mg/L) | | 34.58 | 36.99 | 41.15 | 37.57 | 3.3236 | 8.85 |
| 23.3% **Day2** hr 5 rerun | BlnkCorr Signal | | 0.894 | 0.88 | 0.842 | 0.872 | 0.0269 | 3.09 |
| | sample conc (mg/L) | | 47.93 | 46.17 | 42.04 | 45.38 | 3.0234 | 6.66 |
| | Stnd Conc (mg/L) | | 47.93 | 46.17 | 42.04 | 45.38 | 3.0234 | 6.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 7.5 | BlnkCorr Signal | | 0.913 | 0.912 | 0.914 | 0.913 | 0.0010 | 0.11 |
| | sample conc (mg/L) | | 50.66 | 50.45 | 50.78 | 50.63 | 0.1670 | 0.33 |
| | Stnd Conc (mg/L) | | 50.66 | 50.45 | 50.78 | 50.63 | 0.1670 | 0.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 0 | BlnkCorr Signal | | 0.942 | 0.945 | 0.944 | 0.944 | 0.0015 | 0.16 |
| | sample conc (mg/L) | | 55.21 | 55.85 | 55.68 | 55.58 | 0.3315 | 0.60 |
| | Stnd Conc (mg/L) | | 55.21 | 55.85 | 55.68 | 55.58 | 0.3315 | 0.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 3.5 | BlnkCorr Signal | | 0.953 | 0.959 | 0.961 | 0.958 | 0.0042 | 0.43 |
| | sample conc (mg/L) | | 57.31 | 58.42 | 58.83 | 58.19 | 0.7864 | 1.35 |
| | Stnd Conc (mg/L) | | 57.31 | 58.42 | 58.83 | 58.19 | 0.7864 | 1.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 7 | BlnkCorr Signal | | 0.932 | 0.944 | 0.950 | 0.942 | 0.0092 | 0.97 |
| | sample conc (mg/L) | | 53.47 | 55.58 | 56.73 | 55.26 | 1.6534 | 2.99 |
| | Stnd Conc (mg/L) | | 53.47 | 55.58 | 56.73 | 55.26 | 1.6534 | 2.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 0 | BlnkCorr Signal | | 0.970 | 0.967 | 0.967 | 0.968 | 0.0017 | 0.18 |
| | sample conc (mg/L) | | 60.86 | 60.10 | 60.14 | 60.37 | 0.4277 | 0.71 |
| | Stnd Conc (mg/L) | | 60.86 | 60.10 | 60.14 | 60.37 | 0.4277 | 0.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 7 | BlnkCorr Signal | | 0.955 | 0.966 | 0.966 | 0.962 | 0.0064 | 0.66 |
| | sample conc (mg/L) | | 57.68 | 59.89 | 59.98 | 59.18 | 1.3027 | 2.20 |
| | Stnd Conc (mg/L) | | 57.68 | 59.89 | 59.98 | 59.18 | 1.3027 | 2.20 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 | BlnkCorr Signal | | 0.936 | 0.895 | 0.869 | 0.900 | 0.0338 | 3.75 |
| | sample conc (mg/L) | | 57.47 | 48.09 | 44.98 | 50.18 | 6.5020 | 12.96 |
| | Stnd Conc (mg/L) | | 57.47 | 48.09 | 44.98 | 50.18 | 6.5020 | 12.96 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.967 | 0.955 | 0.957 | 0.960 | 0.0064 | 0.67 |
| | sample conc (mg/L) | | 60.11 | 57.58 | 58.03 | 58.57 | 1.3497 | 2.30 |
| | Stnd Conc (mg/L) | | 60.11 | 57.58 | 58.03 | 58.57 | 1.3497 | 2.30 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 0 | BlnkCorr Signal | | 1.007 | 1.007 | 1.019 | 1.011 | 0.0069 | 0.69 |
| | sample conc (mg/L) | | 70.65 | 70.69 | 74.64 | 71.99 | 2.2922 | 3.18 |
| | Stnd Conc (mg/L) | | 70.65 | 70.69 | 74.64 | 71.99 | 2.2922 | 3.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 7 | BlnkCorr Signal | | 1.034 | 0.972 | 0.930 | 0.979 | 0.0523 | 5.35 |
| | sample conc (mg/L) | | 80.49 | 61.31 | 53.15 | 64.98 | 14.0353 | 21.60 |
| | Stnd Conc (mg/L) | | 80.49 | 61.31 | 53.15 | 64.98 | 14.0353 | 21.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 1.029 | 0.994 | 0.987 | 1.003 | 0.0225 | 2.24 |
| | sample conc (mg/L) | | 78.43 | 66.69 | 64.78 | 69.97 | 7.3914 | 10.56 |
| | Stnd Conc (mg/L) | | 78.43 | 66.69 | 64.78 | 69.97 | 7.3914 | 10.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 1.041 | 1.032 | 1.040 | 1.038 | 0.0049 | 0.48 |
| | sample conc (mg/L) | | 83.73 | 79.99 | 83.57 | 82.43 | 2.1146 | 2.57 |
| | Stnd Conc (mg/L) | | 83.73 | 79.99 | 83.57 | 82.43 | 2.1146 | 2.57 |

### 7.5.3. Appendix 5c - Cobalt Temperature raw data

**5% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 19.50 |
| | 2 | 19.50 |
| | 3 | 18.50 |
| | 4 | 18.50 |
| | 5 | 18.75 |
| | 6 | 19.00 |
| 2 | 24 | 19.00 |
| | 26.5 | 19.75 |
| | 29 | 20.25 |
| | 31.5 | 20.75 |
| 3 | 48 | 20.00 |
| | 51.5 | 20.00 |
| | 55 | 19.75 |
| 4 | 72 | 21.00 |
| | 79 | 21.75 |
| | **84.5** | 23.00 |
| 5 | 96.5 | 21.25 |
| | 103.5 | 21.25 |
| 8 | **168** | 20.00 |

**14.15% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 20.50 |
| | 2 | 19.75 |
| | 3 | 18.50 |
| | 4 | 18.50 |
| | 5 | 18.50 |
| | 6 | 18.75 |
| 2 | 24 | 18.75 |
| | 26.5 | 19.50 |
| | 29 | 20.00 |
| | 31.5 | 20.25 |
| 3 | 48 | 19.50 |
| | 51.5 | 20.00 |
| | 55 | 19.25 |
| 4 | 72 | 20.50 |
| | 79 | 21.50 |
| | **84.5** | 22.75 |
| 5 | 96.5 | 21.00 |
| | 103.5 | 21.00 |
| 8 | **168** | 20.00 |

**23.3% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 22.00 |
| | 2 | 22.50 |
| | 3 | 22.00 |
| | 4 | 19.00 |
| | 5 | 19.00 |
| | 6 | 19.00 |
| 2 | 24 | 19.00 |
| | 26.5 | 20.00 |
| | 29 | 20.50 |
| | 31.5 | 20.50 |

| Day | Hours | Temperature (°C) |
|---|---|---|
| 3 | 48 | 20.00 |
| | 51.5 | 20.25 |
| | 55 | 20.00 |
| 4 | 72 | 21.00 |
| | 79 | 22.00 |
| | **84.5** | 23.50 |
| 5 | 96.5 | 21.50 |
| | 103.5 | 22.00 |
| 8 | **168** | 21.00 |

### 7.6.1. Appendix 6a - Rhenium Calibration graph raw data

range: 50 - 1000 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 0.591 | 0.591 | 0.00058 | 0.10 |
| | 0.591 | | | |
| | 0.592 | | | |
| 50 | 0.012 | 0.012 | 0.00058 | 4.81 |
| | 0.011 | | | |
| | 0.012 | | | |
| 250 | 0.052 | 0.052 | 0.00058 | 1.11 |
| | 0.052 | | | |
| | 0.051 | | | |
| 650 | 0.123 | 0.124 | 0.00058 | 0.47 |
| | 0.124 | | | |
| | 0.124 | | | |
| 1000 | 0.187 | 0.187 | 0.00058 | 0.31 |
| | 0.186 | | | |
| | 0.187 | | | |

### 7.6.2. Appendix 6b - Rhenium AAS raw data

**5% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 | BlnkCorr Signal | | 0.010 | 0.011 | 0.010 | 0.010 | 0.0006 | 5.59 |
| | sample conc (mg/L) | | 46.99 | 47.56 | 47.01 | 47.19 | 0.3235 | 0.69 |
| | Stnd Conc (mg/L) | | 46.99 | 47.56 | 47.01 | 47.19 | 0.3235 | 0.69 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 R | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 47.45 | 48.25 | 47.98 | 47.89 | 0.4070 | 0.85 |
| | Stnd Conc (mg/L) | | 47.45 | 48.25 | 47.98 | 47.89 | 0.4070 | 0.85 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 2 | BlnkCorr Signal | | 0.011 | 0.011 | 0.010 | 0.011 | 0.0006 | 5.41 |
| | sample conc (mg/L) | | 48.43 | 49.13 | 47.69 | 48.42 | 0.7201 | 1.49 |
| | Stnd Conc (mg/L) | | 48.43 | 49.13 | 47.69 | 48.42 | 0.7201 | 1.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 3 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 47.28 | 48.56 | 48.59 | 48.14 | 0.7478 | 1.55 |
| | Stnd Conc (mg/L) | | 47.28 | 48.56 | 48.59 | 48.14 | 0.7478 | 1.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 4 | BlnkCorr Signal | | 0.011 | 0.012 | 0.011 | 0.011 | 0.0006 | 5.59 |
| | sample conc (mg/L) | | 48.75 | 50.36 | 47.65 | 48.92 | 1.3630 | 2.79 |
| | Stnd Conc (mg/L) | | 48.75 | 50.36 | 47.65 | 48.92 | 1.3630 | 2.79 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 5 | BlnkCorr Signal | | 0.011 | 0.011 | 0.012 | 0.011 | 0.0006 | 5.09 |
| | sample conc (mg/L) | | 49.16 | 48.99 | 50.67 | 49.61 | 0.9248 | 1.86 |
| | Stnd Conc (mg/L) | | 49.16 | 48.99 | 50.67 | 49.61 | 0.9248 | 1.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 6 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 50.09 | 50.80 | 52.52 | 51.14 | 1.2495 | 2.44 |
| | Stnd Conc (mg/L) | | 50.09 | 50.80 | 52.52 | 51.14 | 1.2495 | 2.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 0 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 50.34 | 50.31 | 50.31 | 50.32 | 0.0173 | 0.03 |
| | Stnd Conc (mg/L) | | 50.34 | 50.31 | 50.31 | 50.32 | 0.0173 | 0.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 2.5 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 51.92 | 50.99 | 51.42 | 51.44 | 0.4654 | 0.90 |
| | Stnd Conc (mg/L) | | 51.92 | 50.99 | 51.42 | 51.44 | 0.4654 | 0.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 5 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 52.17 | 52.08 | 51.15 | 51.80 | 0.5647 | 1.09 |
| | Stnd Conc (mg/L) | | 52.17 | 52.08 | 51.15 | 51.80 | 0.5647 | 1.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 7.5 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 52.69 | 53.06 | 52.30 | 52.68 | 0.3800 | 0.72 |
| | Stnd Conc (mg/L) | | 52.69 | 53.06 | 52.30 | 52.68 | 0.3800 | 0.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 0 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 52.43 | 52.52 | 51.93 | 52.29 | 0.3179 | 0.61 |
| | Stnd Conc (mg/L) | | 52.43 | 52.52 | 51.93 | 52.29 | 0.3179 | 0.61 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 3.5 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 52.10 | 53.20 | 53.47 | 52.92 | 0.7257 | 1.37 |
| | Stnd Conc (mg/L) | | 52.10 | 53.20 | 53.47 | 52.92 | 0.7257 | 1.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 7 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 53.41 | 53.05 | 52.29 | 52.92 | 0.5718 | 1.08 |
| | Stnd Conc (mg/L) | | 53.41 | 53.05 | 52.29 | 52.92 | 0.5718 | 1.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 0 | BlnkCorr Signal | | 0.012 | 0.013 | 0.013 | 0.013 | 0.0006 | 4.56 |
| | sample conc (mg/L) | | 53.11 | 54.24 | 55.14 | 54.16 | 1.0172 | 1.88 |
| | Stnd Conc (mg/L) | | 53.11 | 54.24 | 55.14 | 54.16 | 1.0172 | 1.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 7 | BlnkCorr Signal | | 0.013 | 0.013 | 0.012 | 0.013 | 0.0006 | 4.56 |
| | sample conc (mg/L) | | 54.26 | 55.37 | 54.02 | 54.55 | 0.7202 | 1.32 |
| | Stnd Conc (mg/L) | | 54.26 | 55.37 | 54.02 | 54.55 | 0.7202 | 1.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.22 | 55.82 | 54.88 | 55.31 | 0.4760 | 0.86 |
| | Stnd Conc (mg/L) | | 55.22 | 55.82 | 54.88 | 55.31 | 0.4760 | 0.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.013 | 0.012 | 0.013 | 0.013 | 0.0006 | 4.56 |
| | sample conc (mg/L) | | 54.91 | 54.10 | 54.56 | 54.52 | 0.4062 | 0.75 |
| | Stnd Conc (mg/L) | | 54.91 | 54.10 | 54.56 | 54.52 | 0.4062 | 0.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day5** hr 0 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.89 | 54.53 | 56.50 | 55.31 | 1.0490 | 1.90 |
| | Stnd Conc (mg/L) | | 54.89 | 54.53 | 56.50 | 55.31 | 1.0490 | 1.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day5** hr 7 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.81 | 55.33 | 55.26 | 55.13 | 0.2822 | 0.51 |
| | Stnd Conc (mg/L) | | 54.81 | 55.33 | 55.26 | 55.13 | 0.2822 | 0.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.29 | 56.08 | 55.63 | 55.33 | 0.9311 | 1.68 |
| | Stnd Conc (mg/L) | | 55.29 | 56.08 | 55.63 | 55.67 | 0.3963 | 0.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.96 | 55.31 | 55.77 | 55.68 | 0.3342 | 0.60 |
| | Stnd Conc (mg/L) | | 55.96 | 55.31 | 55.77 | 55.68 | 0.3342 | 0.60 |

## 14.15% aqua regia sample raw data

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.98 | 54.23 | 54.32 | 54.84 | 0.9854 | 1.80 |
| | Stnd Conc (mg/L) | | 55.98 | 54.23 | 54.32 | 54.84 | 0.9854 | 1.80 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 R | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.87 | 55.40 | 54.85 | 55.04 | 0.3119 | 0.57 |
| | Stnd Conc (mg/L) | | 54.87 | 55.40 | 54.85 | 55.04 | 0.3119 | 0.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 2 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.08 | 54.82 | 54.65 | 54.85 | 0.2166 | 0.39 |
| | Stnd Conc (mg/L) | | 55.08 | 54.82 | 54.65 | 54.85 | 0.2166 | 0.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 3 | BlnkCorr Signal | | 0.012 | 0.013 | 0.013 | 0.013 | 0.0006 | 4.56 |
| | sample conc (mg/L) | | 54.19 | 54.43 | 56.03 | 54.88 | 1.0003 | 1.82 |
| | Stnd Conc (mg/L) | | 54.19 | 54.43 | 56.03 | 54.88 | 1.0003 | 1.82 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 4 | BlnkCorr Signal | | 0.012 | 0.013 | 0.012 | 0.012 | 0.0006 | 4.68 |
| | sample conc (mg/L) | | 53.90 | 54.47 | 53.76 | 54.04 | 0.3761 | 0.70 |
| | Stnd Conc (mg/L) | | 53.90 | 54.47 | 53.76 | 54.04 | 0.3761 | 0.70 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 5 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.60 | 54.36 | 54.54 | 54.83 | 0.6700 | 1.22 |
| | Stnd Conc (mg/L) | | 55.60 | 54.36 | 54.54 | 54.83 | 0.6700 | 1.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 6 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.07 | 55.95 | 55.91 | 55.64 | 0.4969 | 0.89 |
| | Stnd Conc (mg/L) | | 55.07 | 55.95 | 55.91 | 55.64 | 0.4969 | 0.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 0 | BlnkCorr Signal | | 0.015 | 0.016 | 0.015 | 0.015 | 0.0006 | 3.77 |
| | sample conc (mg/L) | | 68.08 | 68.34 | 67.95 | 68.12 | 0.1986 | 0.29 |
| | Stnd Conc (mg/L) | | 68.08 | 68.34 | 67.95 | 68.12 | 0.1986 | 0.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 2.5 | BlnkCorr Signal | | 0.015 | 0.015 | 0.016 | 0.015 | 0.0006 | 3.77 |
| | sample conc (mg/L) | | 67.26 | 68.09 | 68.73 | 68.03 | 0.7370 | 1.08 |
| | Stnd Conc (mg/L) | | 67.26 | 68.09 | 68.73 | 68.03 | 0.7370 | 1.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 5 | BlnkCorr Signal | | 0.015 | 0.016 | 0.016 | 0.016 | 0.0006 | 3.69 |
| | sample conc (mg/L) | | 67.96 | 69.61 | 69.10 | 68.89 | 0.8448 | 1.23 |
| | Stnd Conc (mg/L) | | 67.96 | 69.61 | 69.10 | 68.89 | 0.8448 | 1.23 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 7.5 | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 70.78 | 68.23 | 69.46 | 69.49 | 1.2753 | 1.84 |
| | Stnd Conc (mg/L) | | 70.78 | 68.23 | 69.46 | 69.49 | 1.2753 | 1.84 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 0 | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 70.36 | 71.60 | 70.85 | 70.94 | 0.6245 | 0.88 |
| | Stnd Conc (mg/L) | | 70.36 | 71.60 | 70.85 | 70.94 | 0.6245 | 0.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 3.5 | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 71.25 | 72.20 | 72.16 | 71.87 | 0.5373 | 0.75 |
| | Stnd Conc (mg/L) | | 71.25 | 72.20 | 72.16 | 71.87 | 0.5373 | 0.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 7 | BlnkCorr Signal | | 0.016 | 0.016 | 0.017 | 0.016 | 0.0006 | 3.53 |
| | sample conc (mg/L) | | 72.30 | 72.35 | 73.48 | 72.71 | 0.6673 | 0.92 |
| | Stnd Conc (mg/L) | | 72.30 | 72.35 | 73.48 | 72.71 | 0.6673 | 0.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 0 | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 74.38 | 74.28 | 74.36 | 74.34 | 0.0529 | 0.07 |
| | Stnd Conc (mg/L) | | 74.38 | 74.28 | 74.36 | 74.34 | 0.0529 | 0.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 76.03 | 75.46 | 76.41 | 75.97 | 0.4782 | 0.63 |
| | Stnd Conc (mg/L) | | 76.03 | 75.46 | 76.41 | 75.97 | 0.4782 | 0.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 75.70 | 75.86 | 76.81 | 76.12 | 0.6000 | 0.79 |
| | Stnd Conc (mg/L) | | 75.70 | 75.86 | 76.81 | 76.12 | 0.6000 | 0.79 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 76.55 | 76.17 | 76.80 | 76.51 | 0.3172 | 0.41 |
| | Stnd Conc (mg/L) | | 76.55 | 76.17 | 76.80 | 76.51 | 0.3172 | 0.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RR | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 77.08 | 76.57 | 77.15 | 76.93 | 0.3166 | 0.41 |
| | Stnd Conc (mg/L) | | 77.08 | 76.57 | 77.15 | 76.93 | 0.3166 | 0.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RRR | BlnkCorr Signal | | 0.017 | 0.017 | 0.018 | 0.017 | 0.0006 | 3.33 |
| | sample conc (mg/L) | | 76.63 | 76.46 | 78.12 | 77.07 | 0.9133 | 1.19 |
| | Stnd Conc (mg/L) | | 76.63 | 76.46 | 78.12 | 77.07 | 0.9133 | 1.19 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day5** hr 0 | BlnkCorr Signal | | 0.018 | 0.017 | 0.017 | 0.017 | 0.0006 | 3.33 |
| | sample conc (mg/L) | | 78.22 | 76.50 | 77.62 | 77.45 | 0.8730 | 1.13 |
| | Stnd Conc (mg/L) | | 78.22 | 76.50 | 77.62 | 77.45 | 0.8730 | 1.13 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day5** hr 7 | BlnkCorr Signal | | 0.018 | 0.018 | 0.018 | 0.018 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 77.77 | 78.43 | 77.86 | 78.02 | 0.3579 | 0.46 |
| | Stnd Conc (mg/L) | | 77.77 | 78.43 | 77.86 | 78.02 | 0.3579 | 0.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.018 | 0.018 | 0.018 | 0.018 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 78.05 | 77.97 | 77.94 | 77.99 | 0.0569 | 0.07 |
| | Stnd Conc (mg/L) | | 78.05 | 77.97 | 77.94 | 77.99 | 0.0569 | 0.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 76.56 | 76.14 | 76.50 | 76.40 | 0.2272 | 0.30 |
| | Stnd Conc (mg/L) | | 76.56 | 76.14 | 76.50 | 76.40 | 0.2272 | 0.30 |

### 7.6.3. Appendix 6c - Rhenium Temperature raw data

**5% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 27.00 |
| | 2 | 25.50 |
| | 3 | 24.00 |
| | 4 | 24.00 |
| | 5 | 24.50 |
| | 6 | 24.50 |
| 2 | 24 | 24.50 |
| | 26.5 | 25.00 |
| | 29 | 25.75 |
| | 31.5 | 26.00 |
| 3 | 48 | 23.25 |
| | 51.5 | 25.00 |
| | 55 | 25.25 |
| 4 | 72 | 22.50 |
| | 79 | 24.00 |
| | **84.5** | 24.00 |
| 5 | 96.5 | 23.00 |
| | 103.5 | 23.50 |
| 8 | **168** | 21.75 |

**14.15% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 28.00 |
| | 2 | 25.00 |
| | 3 | 23.50 |
| | 4 | 23.00 |
| | 5 | 23.00 |
| | 6 | 23.00 |
| 2 | 24 | 21.50 |
| | 26.5 | 22.00 |
| | 29 | 22.25 |
| | 31.5 | 23.00 |
| 3 | 48 | 22.50 |
| | 51.5 | 22.50 |
| | 55 | 23.25 |
| 4 | 72 | 22.25 |
| | 79 | 23.00 |
| | **84.5** | 23.75 |
| 5 | 96.5 | 24.00 |
| | 103.5 | 23.75 |
| 8 | **168** | 21.50 |

### 7.7.1. Appendix 7a - Rhenium (from super alloy) Calibration graph raw data

range: 50 - 1000 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 0.486 | 0.486 | 0.00000 | 0.00 |
| | 0.486 | | | |
| | 0.486 | | | |
| 50 | 0.008 | 0.008 | 0.00058 | 7.22 |
| | 0.008 | | | |
| | 0.009 | | | |
| 250 | 0.041 | 0.041 | 0.00000 | 0.00 |
| | 0.041 | | | |
| | 0.041 | | | |
| 650 | 0.101 | 0.102 | 0.00058 | 0.57 |
| | 0.102 | | | |
| | 0.102 | | | |
| 1000 | 0.157 | 0.151 | 0.01012 | 6.70 |
| | 0.156 | | | |
| | 0.139 | | | |

### 7.7.2. Appendix 7b - Rhenium (from super alloy) AAS raw data

**23.3% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 48.71 | 48.73 | 49.45 | 48.96 | 0.4216 | 0.86 |
| | Stnd Conc (mg/L) | | 48.71 | 48.73 | 49.45 | 48.96 | 0.4216 | 0.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 R | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 49.97 | 50.58 | 51.13 | 50.56 | 0.5803 | 1.15 |
| | Stnd Conc (mg/L) | | 49.97 | 50.58 | 51.13 | 50.56 | 0.5803 | 1.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 2 | BlnkCorr Signal | | 0.009 | 0.008 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 50.07 | 49.90 | 51.50 | 50.49 | 0.8788 | 1.74 |
| | Stnd Conc (mg/L) | | 50.07 | 49.90 | 51.50 | 50.49 | 0.8788 | 1.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 3 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 51.77 | 51.11 | 52.02 | 51.63 | 0.4701 | 0.91 |
| | Stnd Conc (mg/L) | | 51.77 | 51.11 | 52.02 | 51.63 | 0.4701 | 0.91 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 4 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 51.16 | 50.98 | 52.69 | 51.61 | 0.9396 | 1.82 |
| | Stnd Conc (mg/L) | | 51.16 | 50.98 | 52.69 | 51.61 | 0.9396 | 1.82 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 50.95 | 51.21 | 51.77 | 51.31 | 0.4190 | 0.82 |
| | Stnd Conc (mg/L) | | 50.95 | 51.21 | 51.77 | 51.31 | 0.4190 | 0.82 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 6 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 51.14 | 51.79 | 51.04 | 51.32 | 0.4072 | 0.79 |
| | Stnd Conc (mg/L) | | 51.14 | 51.79 | 51.04 | 51.32 | 0.4072 | 0.79 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 0 | BlnkCorr Signal | | 0.008 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 49.55 | 51.03 | 51.26 | 50.61 | 0.9280 | 1.83 |
| | Stnd Conc (mg/L) | | 49.55 | 51.03 | 51.26 | 50.61 | 0.9280 | 1.83 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 2.5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.008 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 50.62 | 49.96 | 49.86 | 50.15 | 0.4130 | 0.82 |
| | Stnd Conc (mg/L) | | 50.62 | 49.96 | 49.86 | 50.15 | 0.4130 | 0.82 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 5 | BlnkCorr Signal | | 0.008 | 0.008 | 0.009 | 0.008 | 0.0006 | 6.93 |
| | sample conc (mg/L) | | 48.96 | 49.87 | 49.99 | 49.61 | 0.5632 | 1.14 |
| | Stnd Conc (mg/L) | | 48.96 | 49.87 | 49.99 | 49.61 | 0.5632 | 1.14 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 7.5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 50.12 | 50.65 | 50.16 | 50.31 | 0.2951 | 0.59 |
| | Stnd Conc (mg/L) | | 50.12 | 50.65 | 50.16 | 50.31 | 0.2951 | 0.59 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 0 | BlnkCorr Signal | | 0.009 | 0.009 | 0.008 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 49.95 | 50.34 | 49.34 | 49.88 | 0.5040 | 1.01 |
| | Stnd Conc (mg/L) | | 49.95 | 50.34 | 49.34 | 49.88 | 0.5040 | 1.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 3.5 | BlnkCorr Signal | | 0.009 | 0.008 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 50.28 | 49.33 | 51.49 | 50.37 | 1.0826 | 2.15 |
| | Stnd Conc (mg/L) | | 50.28 | 49.33 | 51.49 | 50.37 | 1.0826 | 2.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 7 | BlnkCorr Signal | | 0.009 | 0.008 | 0.008 | 0.008 | 0.0006 | 6.93 |
| | sample conc (mg/L) | | 50.23 | 49.79 | 49.11 | 49.71 | 0.5643 | 1.14 |
| | Stnd Conc (mg/L) | | 50.23 | 49.79 | 49.11 | 49.71 | 0.5643 | 1.14 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 0 | BlnkCorr Signal | | 0.008 | 0.009 | 0.008 | 0.008 | 0.0006 | 6.93 |
| | sample conc (mg/L) | | 48.91 | 51.08 | 48.85 | 49.61 | 1.2705 | 2.56 |
| | Stnd Conc (mg/L) | | 48.91 | 51.08 | 48.85 | 49.61 | 1.2705 | 2.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 7 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 50.02 | 50.94 | 51.09 | 50.68 | 0.5793 | 1.14 |
| | Stnd Conc (mg/L) | | 50.02 | 50.94 | 51.09 | 50.68 | 0.5793 | 1.14 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 | BlnkCorr Signal | | 0.008 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 49.49 | 50.02 | 50.76 | 50.09 | 0.6379 | 1.27 |
| | Stnd Conc (mg/L) | | 49.49 | 50.02 | 50.76 | 50.09 | 0.6379 | 1.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.009 | 0.009 | 0.008 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 52.76 | 50.03 | 49.49 | 50.76 | 1.7530 | 3.45 |
| | Stnd Conc (mg/L) | | 52.76 | 50.03 | 49.49 | 50.76 | 1.7530 | 3.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 0 | BlnkCorr Signal | | 0.008 | 0.009 | 0.008 | 0.008 | 0.0006 | 6.93 |
| | sample conc (mg/L) | | 49.01 | 50.57 | 49.03 | 49.54 | 0.8949 | 1.81 |
| | Stnd Conc (mg/L) | | 49.01 | 50.57 | 49.03 | 49.54 | 0.8949 | 1.81 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 7 | BlnkCorr Signal | | 0.008 | 0.008 | 0.009 | 0.008 | 0.0006 | 6.93 |
| | sample conc (mg/L) | | 49.75 | 49.69 | 50.57 | 50.00 | 0.4917 | 0.98 |
| | Stnd Conc (mg/L) | | 49.75 | 49.69 | 50.57 | 50.00 | 0.4917 | 0.98 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.008 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 48.76 | 50.40 | 49.99 | 49.72 | 0.8535 | 1.72 |
| | Stnd Conc (mg/L) | | 48.76 | 50.40 | 49.99 | 49.72 | 0.8535 | 1.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.009 | 0.009 | 0.008 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 50.92 | 50.16 | 49.58 | 50.22 | 0.6720 | 1.34 |
| | Stnd Conc (mg/L) | | 50.92 | 50.16 | 49.58 | 50.22 | 0.6720 | 1.34 |

### 7.7.3. Appendix 7c - Rhenium (from super alloy) Temperature raw data

**23.3% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 20.00 |
| | 2 | 20.50 |
| | 3 | 20.50 |
| | 4 | 20.75 |
| | 5 | 20.75 |
| | 6 | 20.50 |
| 2 | 24 | 21.25 |
| | 26.5 | 21.25 |
| | 29 | 21.50 |
| | 31.5 | 21.50 |
| 3 | 48 | 21.00 |
| | 51.5 | 21.50 |
| | 55 | 21.50 |
| 4 | 72 | 21.75 |
| | 79 | 21.00 |
| | **84.5** | 21.00 |
| 7 | 144 | 20.75 |
| | 151 | 21.25 |
| 8 | **168** | 21.50 |

### 7.8.1. Appendix 8a - Rhenium (Ultra sonic method) Calibration graph raw data

range: 50 - 1000 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 0.596 | 0.597 | 0.00058 | 0.10 |
| | 0.597 | | | |
| | 0.597 | | | |
| 50 | 0.012 | 0.012 | 0.00000 | 0.00 |
| | 0.012 | | | |
| | 0.012 | | | |
| 250 | 0.051 | 0.051 | 0.00000 | 0.00 |
| | 0.051 | | | |
| | 0.051 | | | |
| 650 | 0.122 | 0.121 | 0.00058 | 0.48 |
| | 0.121 | | | |
| | 0.121 | | | |
| 1000 | 0.186 | 0.184 | 0.00153 | 0.83 |
| | 0.184 | | | |
| | 0.183 | | | |

### 7.8.2. Appendix 8b - Rhenium (ultra sonic method) AAS raw data

**<u>5% aqua regia sample raw data</u>**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 | BlnkCorr Signal | | 0.005 | 0.006 | 0.006 | 0.006 | 0.0006 | 10.19 |
| | sample conc (mg/L) | | 21.20 | 22.44 | 23.17 | 22.27 | 0.9959 | 4.47 |
| | Stnd Conc (mg/L) | | 21.20 | 22.44 | 23.17 | 22.27 | 0.9959 | 4.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 R | BlnkCorr Signal | | 0.006 | 0.006 | 0.007 | 0.006 | 0.0006 | 9.12 |
| | sample conc (mg/L) | | 25.17 | 25.53 | 26.54 | 25.75 | 0.7102 | 2.76 |
| | Stnd Conc (mg/L) | | 25.17 | 25.53 | 26.54 | 25.75 | 0.7102 | 2.76 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 2 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 28.12 | 28.12 | 29.43 | 28.56 | 0.7563 | 2.65 |
| | Stnd Conc (mg/L) | | 28.18 | 28.18 | 29.43 | 28.60 | 0.7217 | 2.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 3 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 31.69 | 32.23 | 32.25 | 32.06 | 0.3177 | 0.99 |
| | Stnd Conc (mg/L) | | 31.69 | 32.23 | 32.25 | 32.06 | 0.3177 | 0.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 4 | BlnkCorr Signal | | 0.008 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.66 |
| | sample conc (mg/L) | | 33.74 | 35.17 | 34.73 | 34.55 | 0.7324 | 2.12 |
| | Stnd Conc (mg/L) | | 33.74 | 35.17 | 34.73 | 34.55 | 0.7324 | 2.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 35.98 | 34.87 | 36.93 | 35.93 | 1.0310 | 2.87 |
| | Stnd Conc (mg/L) | | 35.98 | 34.87 | 36.93 | 35.93 | 1.0310 | 2.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 6 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 39.17 | 40.10 | 39.94 | 39.74 | 0.4972 | 1.25 |
| | Stnd Conc (mg/L) | | 39.17 | 40.10 | 39.94 | 39.74 | 0.4972 | 1.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 0 | BlnkCorr Signal | | 0.010 | 0.010 | 0.011 | 0.010 | 0.0006 | 5.59 |
| | sample conc (mg/L) | | 42.13 | 43.24 | 44.02 | 43.13 | 0.9498 | 2.20 |
| | Stnd Conc (mg/L) | | 42.13 | 43.24 | 44.02 | 43.13 | 0.9498 | 2.20 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 2.5 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 45.34 | 46.71 | 46.20 | 46.08 | 0.6924 | 1.50 |
| | Stnd Conc (mg/L) | | 45.34 | 46.71 | 46.20 | 46.08 | 0.6924 | 1.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 5 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 48.72 | 48.77 | 48.13 | 48.54 | 0.3559 | 0.73 |
| | Stnd Conc (mg/L) | | 48.72 | 48.77 | 48.13 | 48.54 | 0.3559 | 0.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 7.5 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 49.94 | 50.80 | 51.18 | 50.64 | 0.6353 | 1.25 |
| | Stnd Conc (mg/L) | | 49.94 | 50.80 | 51.18 | 50.64 | 0.6353 | 1.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 0 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.68 | 54.55 | 56.36 | 55.20 | 1.0096 | 1.83 |
| | Stnd Conc (mg/L) | | 54.68 | 54.55 | 56.36 | 55.20 | 1.0096 | 1.83 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 3.5 | BlnkCorr Signal | | 0.014 | 0.014 | 0.014 | 0.014 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 58.85 | 59.03 | 60.44 | 59.44 | 0.8707 | 1.46 |
| | Stnd Conc (mg/L) | | 58.85 | 59.03 | 60.44 | 59.44 | 0.8707 | 1.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 7 | BlnkCorr Signal | | 0.015 | 0.015 | 0.015 | 0.015 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 62.55 | 63.58 | 64.67 | 63.60 | 1.0601 | 1.67 |
| | Stnd Conc (mg/L) | | 62.55 | 63.58 | 64.67 | 63.60 | 1.0601 | 1.67 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 0 | BlnkCorr Signal | | 0.015 | 0.016 | 0.015 | 0.015 | 0.0006 | 3.77 |
| | sample conc (mg/L) | | 65.86 | 66.80 | 66.12 | 66.26 | 0.4854 | 0.73 |
| | Stnd Conc (mg/L) | | 65.86 | 66.80 | 66.12 | 66.26 | 0.4854 | 0.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 7 | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 69.52 | 69.66 | 69.33 | 69.50 | 0.1656 | 0.24 |
| | Stnd Conc (mg/L) | | 69.52 | 69.66 | 69.33 | 69.50 | 0.1656 | 0.24 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 70.32 | 70.99 | 70.11 | 70.47 | 0.4596 | 0.65 |
| | Stnd Conc (mg/L) | | 70.32 | 70.99 | 70.11 | 70.47 | 0.4596 | 0.65 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 69.58 | 70.61 | 70.45 | 70.21 | 0.5543 | 0.79 |
| | Stnd Conc (mg/L) | | 69.58 | 70.61 | 70.45 | 70.21 | 0.5543 | 0.79 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day5** hr 0 | BlnkCorr Signal | | 0.016 | 0.016 | 0.017 | 0.016 | 0.0006 | 3.53 |
| | sample conc (mg/L) | | 70.25 | 70.62 | 70.84 | 70.57 | 0.2982 | 0.42 |
| | Stnd Conc (mg/L) | | 70.25 | 70.62 | 70.84 | 70.57 | 0.2982 | 0.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day5** hr 7 | BlnkCorr Signal | | 0.017 | 0.016 | 0.017 | 0.017 | 0.0006 | 3.46 |
| | sample conc (mg/L) | | 71.26 | 70.73 | 71.08 | 71.02 | 0.2695 | 0.38 |
| | Stnd Conc (mg/L) | | 71.26 | 70.73 | 71.08 | 71.02 | 0.2695 | 0.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.017 | 0.017 | 0.016 | 0.017 | 0.0006 | 3.46 |
| | sample conc (mg/L) | | 71.44 | 71.50 | 69.60 | 70.85 | 1.0801 | 1.52 |
| | Stnd Conc (mg/L) | | 71.44 | 71.50 | 69.60 | 70.85 | 1.0801 | 1.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 69.67 | 71.00 | 69.58 | 70.08 | 0.7951 | 1.13 |
| | Stnd Conc (mg/L) | | 69.67 | 71.00 | 69.58 | 70.08 | 0.7951 | 1.13 |

## 14.15% aqua regia raw data

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 | BlnkCorr Signal | | 0.013 | 0.012 | 0.012 | 0.012 | 0.0006 | 4.68 |
| | sample conc (mg/L) | | 52.61 | 50.64 | 51.08 | 51.44 | 1.0340 | 2.01 |
| | Stnd Conc (mg/L) | | 52.61 | 50.64 | 51.08 | 51.44 | 1.0340 | 2.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 R | BlnkCorr Signal | | 0.013 | 0.012 | 0.012 | 0.012 | 0.0006 | 4.68 |
| | sample conc (mg/L) | | 52.77 | 52.12 | 51.08 | 51.99 | 0.8525 | 1.64 |
| | Stnd Conc (mg/L) | | 52.77 | 52.12 | 51.08 | 51.99 | 0.8525 | 1.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 2 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 51.40 | 51.40 | 52.34 | 51.71 | 0.5427 | 1.05 |
| | Stnd Conc (mg/L) | | 51.40 | 51.40 | 52.34 | 51.71 | 0.5427 | 1.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 3 | BlnkCorr Signal | | 0.013 | 0.012 | 0.012 | 0.012 | 0.0006 | 4.68 |
| | sample conc (mg/L) | | 53.27 | 52.43 | 52.56 | 52.75 | 0.4521 | 0.86 |
| | Stnd Conc (mg/L) | | 53.27 | 52.43 | 52.56 | 52.75 | 0.4521 | 0.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 4 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 52.86 | 53.87 | 52.94 | 53.22 | 0.5615 | 1.05 |
| | Stnd Conc (mg/L) | | 52.86 | 53.87 | 52.94 | 53.22 | 0.5615 | 1.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.012 | 0.013 | 0.013 | 0.013 | 0.0006 | 4.56 |
| **Day1** | sample conc (mg/L) | | 51.98 | 52.65 | 52.63 | 52.42 | 0.3812 | 0.73 |
| hr 5 | Stnd Conc (mg/L) | | 51.98 | 52.65 | 52.63 | 52.42 | 0.3812 | 0.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.012 | 0.013 | 0.013 | 0.013 | 0.0006 | 4.56 |
| **Day1** | sample conc (mg/L) | | 52.55 | 52.70 | 52.65 | 52.63 | 0.0764 | 0.15 |
| hr 6 | Stnd Conc (mg/L) | | 52.55 | 52.70 | 52.65 | 52.63 | 0.0764 | 0.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.012 | 0.013 | 0.013 | 0.013 | 0.0006 | 4.56 |
| **Day2** | sample conc (mg/L) | | 52.49 | 53.99 | 53.03 | 53.17 | 0.7597 | 1.43 |
| hr 0 | Stnd Conc (mg/L) | | 52.49 | 53.99 | 53.03 | 53.17 | 0.7597 | 1.43 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| **Day2** | sample conc (mg/L) | | 53.19 | 54.25 | 53.04 | 53.49 | 0.6596 | 1.23 |
| hr 2.5 | Stnd Conc (mg/L) | | 53.19 | 54.25 | 53.04 | 53.49 | 0.6596 | 1.23 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| **Day2** | sample conc (mg/L) | | 53.60 | 53.53 | 54.42 | 53.85 | 0.4949 | 0.92 |
| hr 5 | Stnd Conc (mg/L) | | 53.60 | 53.53 | 54.42 | 53.85 | 0.4949 | 0.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| **Day2** | sample conc (mg/L) | | 54.27 | 53.23 | 54.02 | 53.84 | 0.5429 | 1.01 |
| hr 7.5 | Stnd Conc (mg/L) | | 54.27 | 53.23 | 54.02 | 53.84 | 0.5429 | 1.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| **Day3** | sample conc (mg/L) | | 53.47 | 53.33 | 53.79 | 53.53 | 0.2358 | 0.44 |
| hr 0 | Stnd Conc (mg/L) | | 53.47 | 53.33 | 53.79 | 53.53 | 0.2358 | 0.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| **Day3** | sample conc (mg/L) | | 55.11 | 53.32 | 55.24 | 54.56 | 1.0730 | 1.97 |
| hr 3.5 | Stnd Conc (mg/L) | | 55.11 | 53.32 | 55.24 | 54.56 | 1.0730 | 1.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 7 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.70 | 56.32 | 54.59 | 55.54 | 0.8765 | 1.58 |
| | Stnd Conc (mg/L) | | 55.70 | 56.32 | 54.59 | 55.54 | 0.8765 | 1.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 0 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.85 | 54.67 | 54.75 | 54.76 | 0.0902 | 0.16 |
| | Stnd Conc (mg/L) | | 54.85 | 54.67 | 54.75 | 54.76 | 0.0902 | 0.16 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.78 | 55.13 | 56.96 | 55.62 | 1.1707 | 2.10 |
| | Stnd Conc (mg/L) | | 54.78 | 55.13 | 56.96 | 55.62 | 1.1707 | 2.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.94 | 56.93 | 56.65 | 56.51 | 0.5103 | 0.90 |
| | Stnd Conc (mg/L) | | 55.94 | 56.93 | 56.65 | 56.51 | 0.5103 | 0.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.61 | 55.46 | 56.10 | 55.39 | 0.7475 | 1.35 |
| | Stnd Conc (mg/L) | | 54.61 | 55.46 | 56.10 | 55.39 | 0.7475 | 1.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RR | BlnkCorr Signal | | 0.013 | 0.013 | 0.014 | 0.013 | 0.0006 | 4.33 |
| | sample conc (mg/L) | | 55.69 | 55.41 | 57.25 | 56.12 | 0.9914 | 1.77 |
| | Stnd Conc (mg/L) | | 55.69 | 55.41 | 57.25 | 56.12 | 0.9914 | 1.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RRR | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.60 | 56.33 | 55.46 | 55.80 | 0.4672 | 0.84 |
| | Stnd Conc (mg/L) | | 55.60 | 56.33 | 55.46 | 55.80 | 0.4672 | 0.84 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day5** hr 0 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 57.03 | 55.99 | 56.36 | 56.46 | 0.5272 | 0.93 |
| | Stnd Conc (mg/L) | | 57.03 | 55.99 | 56.36 | 56.46 | 0.5272 | 0.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day5** hr 7 | BlnkCorr Signal | | 0.013 | 0.014 | 0.014 | 0.014 | 0.0006 | 4.22 |
| | sample conc (mg/L) | | 56.66 | 57.58 | 58.51 | 57.58 | 0.9250 | 1.61 |
| | Stnd Conc (mg/L) | | 56.66 | 57.58 | 58.51 | 57.58 | 0.9250 | 1.61 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.013 | 0.014 | 0.013 | 0.013 | 0.0006 | 4.33 |
| | sample conc (mg/L) | | 57.19 | 57.58 | 56.96 | 57.24 | 0.3134 | 0.55 |
| | Stnd Conc (mg/L) | | 57.19 | 57.58 | 56.96 | 57.24 | 0.3134 | 0.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.013 | 0.014 | 0.013 | 0.013 | 0.0006 | 4.33 |
| | sample conc (mg/L) | | 57.03 | 57.28 | 57.04 | 57.12 | 0.1415 | 0.25 |
| | Stnd Conc (mg/L) | | 57.03 | 57.28 | 57.04 | 57.12 | 0.1415 | 0.25 |

### 7.8.3. Appendix 8c - Rhenium (ultra sonic method) Temperature raw data

**5% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 29.75 |
| | 2 | 30.25 |
| | 3 | 31.50 |
| | 4 | 30.75 |
| | 5 | 32.75 |
| | 6 | 34.75 |
| 2 | 24 | 31.00 |
| | 26.5 | 32.25 |
| | 29 | 32.00 |
| | 31.5 | 32.00 |
| 3 | 48 | 30.50 |
| | 51.5 | 31.75 |
| | 55 | 33.00 |
| 4 | 72 | 30.75 |
| | 79 | 32.50 |
| | **84.5** | 32.00 |
| 7 | 144 | 33.00 |
| | 151 | 31.75 |
| 8 | **168** | 30.50 |

**14.15% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 30.50 |
| | 2 | 30.25 |
| | 3 | 32.50 |
| | 4 | 32.25 |
| | 5 | 33.25 |
| | 6 | 34.00 |
| 2 | 24 | 31.25 |
| | 26.5 | 31.00 |
| | 29 | 32.75 |
| | 31.5 | 33.00 |
| 3 | 48 | 33.25 |
| | 51.5 | 32.75 |
| | 55 | 32.00 |
| 4 | 72 | 31.00 |
| | 79 | 31.25 |
| | **84.5** | 31.25 |
| 7 | 144 | 30.25 |
| | 151 | 32.00 |
| 8 | **168** | 31.00 |

### 7.9.1. Appendix 9a - Tungsten Calibration graph raw data

range: 5 - 450 ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| water | 1.297 | 1.297 | 0.00058 | 0.04 |
| | 1.297 | | | |
| | 1.296 | | | |
| 5 | 0.003 | 0.003 | 0.00058 | 19.25 |
| | 0.003 | | | |
| | 0.004 | | | |
| 50 | 0.022 | 0.021 | 0.00100 | 4.76 |
| | 0.021 | | | |
| | 0.020 | | | |
| 250 | 0.093 | 0.093 | 0.00058 | 0.62 |
| | 0.092 | | | |
| | 0.093 | | | |
| 450 | 0.169 | 0.168 | 0.00058 | 0.34 |
| | 0.168 | | | |
| | 0.168 | | | |

### 7.9.2. Appendix 9b - Tungsten AAS raw data

**5% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 | BlnkCorr Signal | | 0.002 | 0.004 | 0.004 | 0.003 | 0.0012 | 34.64 |
| | sample conc (mg/L) | | 3.947 | 5.948 | 6.364 | 5.420 | 1.2922 | 23.84 |
| | Stnd Conc (mg/L) | | 3.947 | 5.948 | 6.364 | 5.420 | 1.2922 | 23.84 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 R | BlnkCorr Signal | | 0.005 | 0.004 | 0.006 | 0.005 | 0.0010 | 20.00 |
| | sample conc (mg/L) | | 7.604 | 6.447 | 10.30 | 8.117 | 1.9771 | 24.36 |
| | Stnd Conc (mg/L) | | 7.604 | 6.447 | 10.30 | 8.117 | 1.9771 | 24.36 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 2 | BlnkCorr Signal | | 0.006 | 0.006 | 0.005 | 0.006 | 0.0006 | 10.19 |
| | sample conc (mg/L) | | 9.716 | 9.865 | 8.848 | 9.476 | 0.5492 | 5.80 |
| | Stnd Conc (mg/L) | | 9.716 | 9.865 | 8.848 | 9.476 | 0.5492 | 5.80 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 3 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 8.261 | 8.394 | 7.634 | 8.096 | 0.4059 | 5.01 |
| | Stnd Conc (mg/L) | | 8.261 | 8.394 | 7.634 | 8.096 | 0.4059 | 5.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 4 | BlnkCorr Signal | | 0.007 | 0.008 | 0.005 | 0.007 | 0.0015 | 22.91 |
| | sample conc (mg/L) | | 11.19 | 13.18 | 8.177 | 10.85 | 2.5189 | 23.22 |
| | Stnd Conc (mg/L) | | 11.19 | 13.18 | 8.177 | 10.85 | 2.5189 | 23.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 5 | BlnkCorr Signal | | 0.005 | 0.006 | 0.006 | 0.006 | 0.0006 | 10.19 |
| | sample conc (mg/L) | | 9.09 | 10.10 | 9.39 | 9.528 | 0.5186 | 5.44 |
| | Stnd Conc (mg/L) | | 9.09 | 10.10 | 9.39 | 9.528 | 0.5186 | 5.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 6 | BlnkCorr Signal | | 0.007 | 0.006 | 0.007 | 0.007 | 0.0006 | 8.66 |
| | sample conc (mg/L) | | 11.68 | 10.36 | 12.24 | 11.43 | 0.9653 | 8.45 |
| | Stnd Conc (mg/L) | | 11.68 | 10.36 | 12.24 | 11.43 | 0.9653 | 8.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 0 | BlnkCorr Signal | | 0.007 | 0.008 | 0.007 | 0.007 | 0.0006 | 7.87 |
| | sample conc (mg/L) | | 11.55 | 14.44 | 11.73 | 12.57 | 1.6191 | 12.88 |
| | Stnd Conc (mg/L) | | 11.55 | 14.44 | 11.73 | 12.57 | 1.6191 | 12.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 2.5 | BlnkCorr Signal | | 0.007 | 0.008 | 0.007 | 0.007 | 0.0006 | 7.87 |
| | sample conc (mg/L) | | 12.25 | 13.88 | 12.62 | 12.92 | 0.8545 | 6.62 |
| | Stnd Conc (mg/L) | | 12.25 | 13.88 | 12.62 | 12.92 | 0.8545 | 6.62 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 5 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 13.65 | 12.88 | 13.56 | 13.36 | 0.4210 | 3.15 |
| | Stnd Conc (mg/L) | | 13.65 | 12.88 | 13.56 | 13.36 | 0.4210 | 3.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 7.5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 15.44 | 14.68 | 14.95 | 15.02 | 0.3853 | 2.56 |
| | Stnd Conc (mg/L) | | 15.44 | 14.68 | 14.95 | 15.02 | 0.3853 | 2.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 0 | BlnkCorr Signal | | 0.007 | 0.010 | 0.008 | 0.008 | 0.0015 | 18.33 |
| | sample conc (mg/L) | | 12.28 | 16.97 | 13.54 | 14.26 | 2.4272 | 17.02 |
| | Stnd Conc (mg/L) | | 12.28 | 16.97 | 13.54 | 14.26 | 2.4272 | 17.02 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 3.5 | BlnkCorr Signal | | 0.008 | 0.100 | 0.009 | 0.039 | 0.0528 | 135.46 |
| | sample conc (mg/L) | | 13.60 | 17.87 | 14.88 | 15.45 | 2.1913 | 14.18 |
| | Stnd Conc (mg/L) | | 13.60 | 17.87 | 14.88 | 15.45 | 2.1913 | 14.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 7 | BlnkCorr Signal | | 0.010 | 0.010 | 0.009 | 0.010 | 0.0006 | 5.97 |
| | sample conc (mg/L) | | 19.96 | 16.82 | 16.24 | 17.67 | 2.0014 | 11.32 |
| | Stnd Conc (mg/L) | | 19.96 | 16.82 | 16.24 | 17.67 | 2.0014 | 11.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 0 | BlnkCorr Signal | | 0.008 | 0.009 | 0.010 | 0.009 | 0.0010 | 11.11 |
| | sample conc (mg/L) | | 14.06 | 16.35 | 17.47 | 15.96 | 1.7381 | 10.89 |
| | Stnd Conc (mg/L) | | 14.06 | 16.35 | 17.47 | 15.96 | 1.7381 | 10.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 7 | BlnkCorr Signal | | 0.010 | 0.010 | 0.009 | 0.010 | 0.0006 | 5.97 |
| | sample conc (mg/L) | | 17.35 | 17.42 | 15.47 | 16.75 | 1.1062 | 6.61 |
| | Stnd Conc (mg/L) | | 17.35 | 17.42 | 15.47 | 16.75 | 1.1062 | 6.61 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 | BlnkCorr Signal | | 0.011 | 0.009 | 0.010 | 0.010 | 0.0010 | 10.00 |
| | sample conc (mg/L) | | 18.80 | 16.29 | 17.07 | 17.39 | 1.2846 | 7.39 |
| | Stnd Conc (mg/L) | | 18.80 | 16.29 | 17.07 | 17.39 | 1.2846 | 7.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.009 | 0.009 | 0.010 | 0.009 | 0.0006 | 6.19 |
| | sample conc (mg/L) | | 15.69 | 16.23 | 17.85 | 16.59 | 1.1241 | 6.78 |
| | Stnd Conc (mg/L) | | 15.69 | 16.23 | 17.85 | 16.59 | 1.1241 | 6.78 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 0 | BlnkCorr Signal | | 0.012 | 0.010 | 0.011 | 0.011 | 0.0010 | 9.09 |
| | sample conc (mg/L) | | 20.65 | 17.60 | 18.46 | 18.90 | 1.5726 | 8.32 |
| | Stnd Conc (mg/L) | | 20.65 | 17.60 | 18.46 | 18.90 | 1.5726 | 8.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 7 | BlnkCorr Signal | | 0.012 | 0.009 | 0.011 | 0.011 | 0.0015 | 14.32 |
| | sample conc (mg/L) | | 20.52 | 16.10 | 19.38 | 18.67 | 2.2947 | 12.29 |
| | Stnd Conc (mg/L) | | 20.52 | 16.10 | 19.38 | 18.67 | 2.2947 | 12.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.010 | 0.009 | 0.010 | 0.010 | 0.0006 | 5.97 |
| | sample conc (mg/L) | | 16.98 | 16.05 | 17.14 | 16.72 | 0.5886 | 3.52 |
| | Stnd Conc (mg/L) | | 16.98 | 16.05 | 17.14 | 16.72 | 0.5886 | 3.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.010 | 0.008 | 0.010 | 0.009 | 0.0012 | 12.37 |
| | sample conc (mg/L) | | 17.90 | 13.81 | 17.97 | 16.56 | 2.3818 | 14.38 |
| | Stnd Conc (mg/L) | | 17.90 | 13.81 | 17.97 | 16.56 | 2.3818 | 14.38 |

**14.15% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 | BlnkCorr Signal | | 0.010 | 0.010 | 0.009 | 0.010 | 0.0006 | 5.97 |
| | sample conc (mg/L) | | 17.86 | 17.06 | 15.37 | 16.76 | 1.2712 | 7.58 |
| | Stnd Conc (mg/L) | | 17.86 | 17.06 | 15.37 | 16.76 | 1.2712 | 7.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 R | BlnkCorr Signal | | 0.011 | 0.011 | 0.008 | 0.010 | 0.0017 | 17.32 |
| | sample conc (mg/L) | | 18.70 | 19.52 | 13.87 | 17.36 | 3.0530 | 17.58 |
| | Stnd Conc (mg/L) | | 18.70 | 19.52 | 13.87 | 17.36 | 3.0530 | 17.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 2 | BlnkCorr Signal | | 0.009 | 0.007 | 0.009 | 0.008 | 0.0012 | 13.86 |
| | sample conc (mg/L) | | 15.82 | 12.70 | 15.13 | 14.55 | 1.6389 | 11.26 |
| | Stnd Conc (mg/L) | | 15.82 | 12.70 | 15.13 | 14.55 | 1.6389 | 11.26 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 3 | BlnkCorr Signal | | 0.010 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.19 |
| | sample conc (mg/L) | | 15.25 | 16.33 | 15.78 | 15.79 | 0.5400 | 3.42 |
| | Stnd Conc (mg/L) | | 15.25 | 16.33 | 15.78 | 15.79 | 0.5400 | 3.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 4 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 15.25 | 16.33 | 15.78 | 15.79 | 0.5400 | 3.42 |
| | Stnd Conc (mg/L) | | 15.25 | 16.33 | 15.78 | 15.79 | 0.5400 | 3.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 5 | BlnkCorr Signal | | 0.010 | 0.011 | 0.009 | 0.010 | 0.0010 | 10.00 |
| | sample conc (mg/L) | | 16.54 | 18.76 | 15.38 | 16.89 | 1.7175 | 10.17 |
| | Stnd Conc (mg/L) | | 16.54 | 18.76 | 15.38 | 16.89 | 1.7175 | 10.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 6 | BlnkCorr Signal | | 0.008 | 0.010 | 0.008 | 0.009 | 0.0012 | 13.32 |
| | sample conc (mg/L) | | 13.60 | 16.46 | 13.22 | 14.43 | 1.7711 | 12.28 |
| | Stnd Conc (mg/L) | | 13.60 | 16.46 | 13.22 | 14.43 | 1.7711 | 12.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 0 | BlnkCorr Signal | | 0.010 | 0.008 | 0.008 | 0.009 | 0.0012 | 13.32 |
| | sample conc (mg/L) | | 17.90 | 13.30 | 13.69 | 14.96 | 2.5507 | 17.05 |
| | Stnd Conc (mg/L) | | 17.90 | 13.30 | 13.69 | 14.96 | 2.5507 | 17.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 2.5 | BlnkCorr Signal | | 0.008 | 0.007 | 0.009 | 0.008 | 0.0010 | 12.50 |
| | sample conc (mg/L) | | 14.40 | 12.81 | 16.39 | 14.53 | 1.7937 | 12.34 |
| | Stnd Conc (mg/L) | | 14.40 | 12.81 | 16.39 | 14.53 | 1.7937 | 12.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 5 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 11.17 | 11.47 | 12.03 | 11.56 | 0.4365 | 3.78 |
| | Stnd Conc (mg/L) | | 11.17 | 11.47 | 12.03 | 11.56 | 0.4365 | 3.78 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 7.5 | BlnkCorr Signal | | 0.009 | 0.006 | 0.008 | 0.008 | 0.0015 | 19.92 |
| | sample conc (mg/L) | | 15.53 | 10.77 | 13.98 | 13.43 | 2.4278 | 18.08 |
| | Stnd Conc (mg/L) | | 15.53 | 10.77 | 13.98 | 13.43 | 2.4278 | 18.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 0 | BlnkCorr Signal | | 0.009 | 0.007 | 0.006 | 0.007 | 0.0015 | 20.83 |
| | sample conc (mg/L) | | 14.80 | 11.93 | 9.36 | 12.03 | 2.7204 | 22.61 |
| | Stnd Conc (mg/L) | | 14.80 | 11.93 | 9.36 | 12.03 | 2.7204 | 22.61 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 3.5 | BlnkCorr Signal | | 0.007 | 0.007 | 0.008 | 0.007 | 0.0006 | 7.87 |
| | sample conc (mg/L) | | 12.27 | 12.78 | 12.93 | 12.66 | 0.3460 | 2.73 |
| | Stnd Conc (mg/L) | | 12.27 | 12.78 | 12.93 | 12.66 | 0.3460 | 2.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 7 | BlnkCorr Signal | | 0.006 | 0.007 | 0.006 | 0.006 | 0.0006 | 9.12 |
| | sample conc (mg/L) | | 9.480 | 12.15 | 10.76 | 10.80 | 1.3354 | 12.37 |
| | Stnd Conc (mg/L) | | 9.480 | 12.15 | 10.76 | 10.80 | 1.3354 | 12.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 0 | BlnkCorr Signal | | 0.006 | 0.008 | 0.007 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 10.74 | 13.81 | 12.49 | 12.35 | 1.5400 | 12.47 |
| | Stnd Conc (mg/L) | | 10.70 | 13.81 | 12.49 | 12.33 | 1.5609 | 12.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 11.25 | 12.26 | 12.62 | 12.04 | 0.7102 | 5.90 |
| | Stnd Conc (mg/L) | | 11.25 | 12.26 | 12.62 | 12.04 | 0.7102 | 5.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 | BlnkCorr Signal | | 0.006 | 0.007 | 0.008 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 10.96 | 11.59 | 12.92 | 11.82 | 1.0006 | 8.46 |
| | Stnd Conc (mg/L) | | 10.96 | 11.59 | 12.92 | 11.82 | 1.0006 | 8.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.004 | 0.007 | 0.007 | 0.006 | 0.0017 | 28.87 |
| | sample conc (mg/L) | | 7.460 | 12.39 | 11.15 | 10.33 | 2.5645 | 24.82 |
| | Stnd Conc (mg/L) | | 7.460 | 12.39 | 11.15 | 10.33 | 2.5645 | 24.82 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RR | BlnkCorr Signal | | 0.004 | 0.007 | 0.008 | 0.006 | 0.0021 | 32.87 |
| | sample conc (mg/L) | | 6.635 | 11.50 | 13.39 | 10.51 | 3.4850 | 33.16 |
| | Stnd Conc (mg/L) | | 6.635 | 11.50 | 13.39 | 10.51 | 3.4850 | 33.16 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RRR | BlnkCorr Signal | | 0.007 | 0.008 | 0.007 | 0.007 | 0.0006 | 7.87 |
| | sample conc (mg/L) | | 12.08 | 13.31 | 11.37 | 12.25 | 0.9815 | 8.01 |
| | Stnd Conc (mg/L) | | 12.08 | 13.31 | 11.37 | 12.25 | 0.9815 | 8.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 0 | BlnkCorr Signal | | 0.009 | 0.006 | 0.007 | 0.007 | 0.0015 | 20.83 |
| | sample conc (mg/L) | | 15.09 | 9.84 | 11.12 | 12.02 | 2.7382 | 22.79 |
| | Stnd Conc (mg/L) | | 15.09 | 9.84 | 11.12 | 12.02 | 2.7382 | 22.79 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 7 | BlnkCorr Signal | | 0.008 | 0.007 | 0.005 | 0.007 | 0.0015 | 22.91 |
| | sample conc (mg/L) | | 12.87 | 12.39 | 7.883 | 11.05 | 2.7512 | 24.90 |
| | Stnd Conc (mg/L) | | 12.87 | 12.39 | 7.883 | 11.05 | 2.7512 | 24.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.006 | 0.008 | 0.007 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 10.92 | 13.42 | 11.28 | 11.87 | 1.3515 | 11.38 |
| | Stnd Conc (mg/L) | | 10.92 | 13.42 | 11.28 | 11.87 | 1.3515 | 11.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.008 | 0.006 | 0.007 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 13.54 | 10.83 | 11.51 | 11.96 | 1.4099 | 11.79 |
| | Stnd Conc (mg/L) | | 13.54 | 10.83 | 11.51 | 11.96 | 1.4099 | 11.79 |

**23.3% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 | BlnkCorr Signal | | 0.006 | 0.005 | 0.006 | 0.006 | 0.0006 | 10.19 |
| | sample conc (mg/L) | | 9.958 | 9.114 | 9.987 | 9.686 | 0.4959 | 5.12 |
| | Stnd Conc (mg/L) | | 9.958 | 9.114 | 9.987 | 9.686 | 0.4959 | 5.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 R | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 8.949 | 9.147 | 8.763 | 8.953 | 0.1920 | 2.14 |
| | Stnd Conc (mg/L) | | 8.949 | 9.147 | 8.763 | 8.953 | 0.1920 | 2.14 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 2 | BlnkCorr Signal | | 0.005 | 0.006 | 0.005 | 0.005 | 0.0006 | 10.83 |
| | sample conc (mg/L) | | 9.018 | 10.80 | 8.740 | 9.519 | 1.1178 | 11.74 |
| | Stnd Conc (mg/L) | | 9.018 | 10.80 | 8.740 | 9.519 | 1.1178 | 11.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 3 | BlnkCorr Signal | | 0.008 | 0.004 | 0.006 | 0.006 | 0.0020 | 33.33 |
| | sample conc (mg/L) | | 12.82 | 7.215 | 9.615 | 9.883 | 2.8121 | 28.45 |
| | Stnd Conc (mg/L) | | 12.82 | 7.150 | 9.615 | 9.862 | 2.8430 | 28.83 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 4 | BlnkCorr Signal | | 0.005 | 0.006 | 0.006 | 0.006 | 0.0006 | 10.19 |
| | sample conc (mg/L) | | 8.952 | 10.01 | 9.909 | 9.624 | 0.5839 | 6.07 |
| | Stnd Conc (mg/L) | | 8.952 | 10.01 | 9.909 | 9.624 | 0.5839 | 6.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 5 | BlnkCorr Signal | | 0.003 | 0.005 | 0.005 | 0.004 | 0.0012 | 26.65 |
| | sample conc (mg/L) | | 5.491 | 8.848 | 8.939 | 7.759 | 1.9650 | 25.32 |
| | Stnd Conc (mg/L) | | 5.491 | 8.848 | 8.939 | 7.759 | 1.9650 | 25.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 6 | BlnkCorr Signal | | 0.006 | 0.003 | 0.005 | 0.005 | 0.0015 | 32.73 |
| | sample conc (mg/L) | | 9.687 | 5.457 | 8.794 | 7.979 | 2.2296 | 27.94 |
| | Stnd Conc (mg/L) | | 9.687 | 5.457 | 8.794 | 7.979 | 2.2296 | 27.94 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 0 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 8.293 | 5.457 | 8.230 | 7.327 | 1.6195 | 22.10 |
| | Stnd Conc (mg/L) | | 8.293 | 5.457 | 8.230 | 7.327 | 1.6195 | 22.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 2.5 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 9.256 | 8.076 | 8.482 | 8.605 | 0.5995 | 6.97 |
| | Stnd Conc (mg/L) | | 9.256 | 8.076 | 8.482 | 8.605 | 0.5995 | 6.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 5 | BlnkCorr Signal | | 0.006 | 0.004 | 0.005 | 0.005 | 0.0010 | 20.00 |
| | sample conc (mg/L) | | 9.590 | 7.570 | 8.440 | 8.533 | 1.0132 | 11.87 |
| | Stnd Conc (mg/L) | | 9.590 | 7.570 | 8.440 | 8.533 | 1.0132 | 11.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 7.5 | BlnkCorr Signal | | 0.004 | 0.004 | 0.008 | 0.005 | 0.0023 | 43.30 |
| | sample conc (mg/L) | | 7.537 | 5.906 | 13.07 | 8.838 | 3.7549 | 42.49 |
| | Stnd Conc (mg/L) | | 7.537 | 5.906 | 13.07 | 8.838 | 3.7549 | 42.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 0 | BlnkCorr Signal | | 0.004 | 0.004 | 0.006 | 0.005 | 0.0012 | 24.74 |
| | sample conc (mg/L) | | 6.437 | 6.750 | 9.695 | 7.627 | 1.7975 | 23.57 |
| | Stnd Conc (mg/L) | | 6.437 | 6.750 | 9.695 | 7.627 | 1.7975 | 23.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 3.5 | BlnkCorr Signal | | 0.005 | 0.006 | 0.005 | 0.005 | 0.0006 | 10.83 |
| | sample conc (mg/L) | | 8.420 | 9.570 | 9.181 | 9.057 | 0.5849 | 6.46 |
| | Stnd Conc (mg/L) | | 8.420 | 9.570 | 9.181 | 9.057 | 0.5849 | 6.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 7 | BlnkCorr Signal | | 0.006 | 0.005 | 0.005 | 0.005 | 0.0006 | 10.83 |
| | sample conc (mg/L) | | 9.302 | 7.951 | 8.772 | 8.675 | 0.6807 | 7.85 |
| | Stnd Conc (mg/L) | | 9.302 | 7.951 | 8.772 | 8.675 | 0.6807 | 7.85 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 0 | BlnkCorr Signal | | 0.006 | 0.005 | 0.003 | 0.005 | 0.0015 | 32.73 |
| | sample conc (mg/L) | | 10.94 | 9.005 | 5.399 | 8.448 | 2.8122 | 33.29 |
| | Stnd Conc (mg/L) | | 10.94 | 9.005 | 5.399 | 8.448 | 2.8122 | 33.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 7 | BlnkCorr Signal | | 0.002 | 0.003 | 0.003 | 0.003 | 0.0006 | 21.65 |
| | sample conc (mg/L) | | 2.935 | 5.117 | 5.396 | 4.483 | 1.3476 | 30.06 |
| | Stnd Conc (mg/L) | | 2.935 | 5.117 | 5.396 | 4.483 | 1.3476 | 30.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 | BlnkCorr Signal | | 0.005 | 0.003 | 0.003 | 0.004 | 0.0012 | 31.49 |
| | sample conc (mg/L) | | 7.775 | 5.623 | 5.415 | 6.271 | 1.3066 | 20.84 |
| | Stnd Conc (mg/L) | | 7.775 | 5.623 | 5.415 | 6.271 | 1.3066 | 20.84 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.003 | 0.003 | 0.005 | 0.004 | 0.0012 | 31.49 |
| | sample conc (mg/L) | | 5.578 | 5.288 | 8.003 | 6.290 | 1.4909 | 23.70 |
| | Stnd Conc (mg/L) | | 5.578 | 5.288 | 8.003 | 6.290 | 1.4909 | 23.70 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 0 | BlnkCorr Signal | | 0.003 | 0.003 | 0.004 | 0.003 | 0.0006 | 17.32 |
| | sample conc (mg/L) | | 4.493 | 5.307 | 6.512 | 5.437 | 1.0158 | 18.68 |
| | Stnd Conc (mg/L) | | 4.493 | 5.307 | 6.512 | 5.437 | 1.0158 | 18.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 7 | BlnkCorr Signal | | 0.002 | 0.003 | 0.003 | 0.003 | 0.0006 | 21.65 |
| | sample conc (mg/L) | | 4.118 | 4.952 | 4.216 | 4.429 | 0.4559 | 10.29 |
| | Stnd Conc (mg/L) | | 4.118 | 4.952 | 4.216 | 4.429 | 0.4559 | 10.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.003 | 0.002 | 0.002 | 0.002 | 0.0006 | 24.74 |
| | sample conc (mg/L) | | 4.797 | 3.493 | 2.635 | 3.642 | 1.0886 | 29.89 |
| | Stnd Conc (mg/L) | | 4.797 | 3.493 | 2.635 | 3.642 | 1.0886 | 29.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.002 | 0.002 | 0.001 | 0.002 | 0.0006 | 34.64 |
| | sample conc (mg/L) | | 3.428 | 4.056 | 1.086 | 2.857 | 1.5653 | 54.79 |
| | Stnd Conc (mg/L) | | 3.428 | 4.056 | 1.086 | 2.857 | 1.5653 | 54.79 |

### 7.9.3. Appendix 9c - Tungsten Temperature raw data

**5% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 20.00 |
| | 2 | 20.75 |
| | 3 | 21.25 |
| | 4 | 21.50 |
| | 5 | 21.75 |
| | 6 | 21.75 |
| 2 | 24 | 21.25 |
| | 26.5 | 21.50 |
| | 29 | 21.50 |
| | 31.5 | 21.50 |
| 3 | 48 | 20.50 |
| | 51.5 | 20.75 |
| | 55 | 21.00 |
| 4 | 72 | 20.75 |
| | 79 | 21.00 |
| | **84.5** | 20.75 |
| 7 | 144 | 20.50 |
| | 151 | 20.75 |
| 8 | **168** | 21.00 |

**14.15% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 21.00 |
| | 2 | 21.00 |
| | 3 | 21.00 |
| | 4 | 21.50 |
| | 5 | 21.50 |
| | 6 | 21.50 |
| 2 | 24 | 21.00 |
| | 26.5 | 21.25 |
| | 29 | 21.50 |
| | 31.5 | 21.50 |
| 3 | 48 | 20.50 |
| | 51.5 | 20.50 |
| | 55 | 21.00 |
| 4 | 72 | 21.00 |
| | 79 | 20.75 |
| | **84.5** | 21.00 |
| 7 | 144 | 20.25 |
| | 151 | 20.25 |
| 8 | **168** | 20.75 |

**23.3% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 17.50 |
| | 2 | 19.50 |
| | 3 | 20.00 |
| | 4 | 20.50 |
| | 5 | 20.50 |
| | 6 | 20.50 |
| 2 | 24 | 21.50 |
| | 26.5 | 21.50 |
| | 29 | 22.00 |
| | 31.5 | 22.00 |

| Day | Hours | Temperature (°C) |
|---|---|---|
| 3 | 48 | 21.00 |
| | 51.5 | 21.25 |
| | 55 | 21.50 |
| 4 | 72 | 21.50 |
| | 79 | 21.50 |
| | **84.5** | 21.00 |
| 7 | 144 | 21.00 |
| | 151 | 21.00 |
| 8 | **168** | 21.50 |

### 7.10.1. Appendix 10a - Titanium Calibration graph raw data

| Concentration (ppb) | BlnkCorr | Peak Area | Peak Height |
|---|---|---|---|
| 20 | 0.0028 | -0.0023 | 0.0108 |
| | 0.0055 | 0.0004 | 0.0108 |
| | 0.0102 | 0.0052 | 0.0104 |
| Average | 0.0062 | 0.0011 | 0.0107 |
| SD | 0.0037 | 0.0038 | 0.0002 |
| RSD% | 60.73 | 345.33 | 2.17 |
| 40 | 0.0162 | 0.0112 | 0.0122 |
| | 0.0197 | 0.0147 | 0.0150 |
| | 0.0187 | 0.0136 | 0.0130 |
| Average | 0.0182 | 0.0132 | 0.0134 |
| SD | 0.0018 | 0.0018 | 0.0014 |
| RSD% | 9.91 | 13.59 | 10.76 |
| 60 | 0.0256 | 0.0205 | 0.0164 |
| | 0.0241 | 0.0190 | 0.0169 |
| | 0.0322 | 0.0272 | 0.0210 |
| Average | 0.0273 | 0.0222 | 0.0181 |
| SD | 0.0043 | 0.0044 | 0.0025 |
| RSD% | 15.78 | 19.64 | 13.94 |
| 80 | 0.0398 | 0.0348 | 0.0261 |
| | 0.0446 | 0.0396 | 0.0291 |
| | 0.0443 | 0.0392 | 0.0263 |
| Average | 0.0429 | 0.0379 | 0.0272 |
| SD | 0.0027 | 0.0027 | 0.0017 |
| RSD% | 6.27 | 7.03 | 6.17 |
| 100 | 0.0531 | 0.0481 | 0.0334 |
| | 0.0531 | 0.0481 | 0.0344 |
| | 0.0561 | 0.0511 | 0.0324 |
| Average | 0.0541 | 0.0491 | 0.0334 |
| SD | 0.0017 | 0.0017 | 0.0010 |
| RSD% | 3.20 | 3.53 | 2.99 |

## 7.10.2. Appendix 10b - Titanium AAS raw data

**5% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 | BlnkCorr Signal | | 0.0150 | 0.0139 | 0.0149 | 0.0146 | 0.0006 | 4.17 |
| | Peak Area | | 0.0150 | 0.0139 | 0.0149 | 0.0146 | 0.0006 | 4.17 |
| | Peak Height | | 0.0099 | 0.0098 | 0.0094 | 0.0097 | 0.0003 | 2.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 1 R | BlnkCorr Signal | | 0.0138 | 0.0115 | 0.0114 | 0.0122 | 0.0014 | 11.10 |
| | Peak Area | | 0.0138 | 0.0115 | 0.0114 | 0.0122 | 0.0014 | 11.10 |
| | Peak Height | | 0.0170 | 0.0102 | 0.0087 | 0.0120 | 0.0044 | 36.96 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 2 | BlnkCorr Signal | | 0.0121 | 0.0106 | 0.0118 | 0.0115 | 0.0008 | 6.90 |
| | Peak Area | | 0.0121 | 0.0106 | 0.0118 | 0.0115 | 0.0008 | 6.90 |
| | Peak Height | | 0.0111 | 0.0088 | 0.0108 | 0.0102 | 0.0013 | 12.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 3 | BlnkCorr Signal | | 0.0118 | 0.0114 | 0.0123 | 0.0118 | 0.0005 | 3.81 |
| | Peak Area | | 0.0118 | 0.0114 | 0.0123 | 0.0118 | 0.0005 | 3.81 |
| | Peak Height | | 0.0090 | 0.0082 | 0.0113 | 0.0095 | 0.0016 | 16.94 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 4 | BlnkCorr Signal | | 0.0122 | 0.0098 | 0.0114 | 0.0111 | 0.0012 | 10.98 |
| | Peak Area | | 0.0122 | 0.0098 | 0.0114 | 0.0111 | 0.0012 | 10.98 |
| | Peak Height | | 0.0114 | 0.0104 | 0.0105 | 0.0108 | 0.0006 | 5.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 5 | BlnkCorr Signal | | 0.0097 | 0.0087 | 0.0106 | 0.0097 | 0.0010 | 9.83 |
| | Peak Area | | 0.0097 | 0.0087 | 0.0106 | 0.0097 | 0.0010 | 9.83 |
| | Peak Height | | 0.0097 | 0.0094 | 0.0100 | 0.0097 | 0.0003 | 3.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day1** hr 6 | BlnkCorr Signal | | 0.0099 | 0.0101 | 0.0094 | 0.0098 | 0.0004 | 3.68 |
| | Peak Area | | 0.0099 | 0.0101 | 0.0094 | 0.0098 | 0.0004 | 3.68 |
| | Peak Height | | 0.0082 | 0.0089 | 0.0095 | 0.0089 | 0.0007 | 7.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 0 | BlnkCorr Signal | | 0.0095 | 0.0085 | 0.0058 | 0.0079 | 0.0019 | 24.13 |
| | Peak Area | | 0.0095 | 0.0085 | 0.0058 | 0.0079 | 0.0019 | 24.13 |
| | Peak Height | | 0.0089 | 0.0096 | 0.0084 | 0.0090 | 0.0006 | 6.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 2.5 | BlnkCorr Signal | | 0.0101 | 0.0111 | 0.0080 | 0.0097 | 0.0016 | 16.26 |
| | Peak Area | | 0.0101 | 0.0111 | 0.0080 | 0.0097 | 0.0016 | 16.26 |
| | Peak Height | | 0.0098 | 0.0109 | 0.0088 | 0.0098 | 0.0011 | 10.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 5 | BlnkCorr Signal | | 0.0097 | 0.0069 | 0.0088 | 0.0085 | 0.0014 | 16.88 |
| | Peak Area | | 0.0097 | 0.0069 | 0.0088 | 0.0085 | 0.0014 | 16.88 |
| | Peak Height | | 0.0098 | 0.0100 | 0.0086 | 0.0095 | 0.0008 | 8.00 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day2** hr 7.5 | BlnkCorr Signal | | 0.0073 | 0.0084 | 0.0071 | 0.0076 | 0.0007 | 9.21 |
| | Peak Area | | 0.0073 | 0.0084 | 0.0071 | 0.0076 | 0.0007 | 9.21 |
| | Peak Height | | 0.0081 | 0.0084 | 0.0092 | 0.0086 | 0.0006 | 6.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 0 | BlnkCorr Signal | | 0.0066 | 0.0080 | 0.0053 | 0.0066 | 0.0014 | 20.36 |
| | Peak Area | | 0.0066 | 0.0080 | 0.0053 | 0.0066 | 0.0014 | 20.36 |
| | Peak Height | | 0.0101 | 0.0095 | 0.0079 | 0.0092 | 0.0011 | 12.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 3.5 | BlnkCorr Signal | | 0.0075 | 0.0063 | 0.0044 | 0.0061 | 0.0016 | 25.77 |
| | Peak Area | | 0.0075 | 0.0063 | 0.0044 | 0.0061 | 0.0016 | 25.77 |
| | Peak Height | | 0.0085 | 0.0100 | 0.0075 | 0.0087 | 0.0013 | 14.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day3** hr 7 | BlnkCorr Signal | | 0.0066 | 0.0062 | 0.0039 | 0.0056 | 0.0015 | 26.18 |
| | Peak Area | | 0.0066 | 0.0062 | 0.0039 | 0.0056 | 0.0015 | 26.18 |
| | Peak Height | | 0.0100 | 0.0099 | 0.0100 | 0.0100 | 0.0001 | 0.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 0 | BlnkCorr Signal | | 0.0067 | 0.0082 | 0.0067 | 0.0072 | 0.0009 | 12.03 |
| | Peak Area | | 0.0067 | 0.0082 | 0.0067 | 0.0072 | 0.0009 | 12.03 |
| | Peak Height | | 0.0094 | 0.0084 | 0.0094 | 0.0091 | 0.0006 | 6.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 7 | BlnkCorr Signal | | 0.0070 | 0.0060 | 0.0036 | 0.0055 | 0.0017 | 31.58 |
| | Peak Area | | 0.0070 | 0.0060 | 0.0036 | 0.0055 | 0.0017 | 31.58 |
| | Peak Height | | 0.0088 | 0.0111 | 0.0097 | 0.0099 | 0.0012 | 11.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 | BlnkCorr Signal | | 0.0051 | 0.0063 | 0.0059 | 0.0058 | 0.0006 | 10.60 |
| | Peak Area | | 0.0051 | 0.0063 | 0.0059 | 0.0058 | 0.0006 | 10.60 |
| | Peak Height | | 0.0080 | 0.0097 | 0.0093 | 0.0090 | 0.0009 | 9.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.0066 | 0.0016 | 0.0070 | 0.0051 | 0.0030 | 59.39 |
| | Peak Area | | 0.0066 | 0.0016 | 0.0070 | 0.0051 | 0.0030 | 59.39 |
| | Peak Height | | 0.0097 | 0.0094 | 0.0088 | 0.0093 | 0.0005 | 4.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 0 | BlnkCorr Signal | | 0.0045 | 0.0045 | 0.0064 | 0.0051 | 0.0011 | 21.37 |
| | Peak Area | | 0.0045 | 0.0045 | 0.0064 | 0.0051 | 0.0011 | 21.37 |
| | Peak Height | | 0.0075 | 0.0064 | 0.0077 | 0.0072 | 0.0007 | 9.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day7** hr 7 | BlnkCorr Signal | | 0.0056 | 0.0053 | 0.0040 | 0.0050 | 0.0009 | 17.12 |
| | Peak Area | | 0.0056 | 0.0053 | 0.0040 | 0.0050 | 0.0009 | 17.12 |
| | Peak Height | | 0.0086 | 0.0075 | 0.0075 | 0.0079 | 0.0006 | 8.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | 0.0047 | 0.0046 | 0.0027 | 0.0040 | 0.0011 | 28.17 |
| | Peak Area | | 0.0047 | 0.0046 | 0.0027 | 0.0040 | 0.0011 | 28.17 |
| | Peak Height | | 0.0077 | 0.0082 | 0.0068 | 0.0076 | 0.0007 | 9.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 5% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.0038 | 0.0049 | 0.0057 | 0.0048 | 0.0010 | 19.87 |
| | Peak Area | | 0.0038 | 0.0049 | 0.0057 | 0.0048 | 0.0010 | 19.87 |
| | Peak Height | | 0.0067 | 0.0081 | 0.0073 | 0.0074 | 0.0007 | 9.53 |

**14.15% aqua regia sample raw data**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 | BlnkCorr Signal | | 0.0043 | 0.0036 | 0.0026 | 0.0035 | 0.0009 | 24.41 |
| | Peak Area | | 0.0043 | 0.0036 | 0.0026 | 0.0035 | 0.0009 | 24.41 |
| | Peak Height | | 0.0085 | 0.0072 | 0.0082 | 0.0080 | 0.0007 | 8.54 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 1 R | BlnkCorr Signal | | 0.0012 | 0.0043 | 0.0035 | 0.0030 | 0.0016 | 53.64 |
| | Peak Area | | 0.0012 | 0.0043 | 0.0035 | 0.0030 | 0.0016 | 53.64 |
| | Peak Height | | 0.0069 | 0.0079 | 0.0076 | 0.0075 | 0.0005 | 6.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 2 | BlnkCorr Signal | | 0.0010 | 0.0039 | 0.0006 | 0.0018 | 0.0018 | 98.23 |
| | Peak Area | | 0.0010 | 0.0039 | 0.0006 | 0.0018 | 0.0018 | 98.23 |
| | Peak Height | | 0.0069 | 0.0098 | 0.0075 | 0.0081 | 0.0015 | 18.98 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 3 | BlnkCorr Signal | | 0.0006 | 0.0034 | 0.0028 | 0.0023 | 0.0015 | 65.04 |
| | Peak Area | | 0.0006 | 0.0034 | 0.0028 | 0.0023 | 0.0015 | 65.04 |
| | Peak Height | | 0.0089 | 0.0084 | 0.0092 | 0.0088 | 0.0004 | 4.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 4 | BlnkCorr Signal | | 0.0006 | 0.0032 | 0.0033 | 0.0024 | 0.0015 | 64.68 |
| | Peak Area | | 0.0006 | 0.0032 | 0.0033 | 0.0024 | 0.0015 | 64.68 |
| | Peak Height | | 0.0077 | 0.0094 | 0.0089 | 0.0087 | 0.0009 | 10.08 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 5 | BlnkCorr Signal | | 0.0001 | 0.0012 | 0.0005 | 0.0006 | 0.0006 | 92.80 |
| | Peak Area | | 0.0001 | 0.0012 | 0.0005 | 0.0006 | 0.0006 | 92.80 |
| | Peak Height | | 0.0072 | 0.0077 | 0.0072 | 0.0074 | 0.0003 | 3.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day1** hr 6 | BlnkCorr Signal | | 0.0026 | 0.0027 | 0.0036 | 0.0030 | 0.0006 | 18.56 |
| | Peak Area | | 0.0026 | 0.0027 | 0.0036 | 0.0030 | 0.0006 | 18.56 |
| | Peak Height | | 0.0087 | 0.0069 | 0.0090 | 0.0082 | 0.0011 | 13.85 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 0 | BlnkCorr Signal | | 0.0004 | 0.0018 | 0.0009 | 0.0010 | 0.0007 | 68.66 |
| | Peak Area | | 0.0004 | 0.0018 | 0.0009 | 0.0010 | 0.0007 | 68.66 |
| | Peak Height | | 0.0069 | 0.0067 | 0.0070 | 0.0069 | 0.0002 | 2.22 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 2.5 | BlnkCorr Signal | 0.0018 | 0.0027 | 0.0003 | 0.0016 | 0.0012 | 75.78 |
| | Peak Area | 0.0018 | 0.0027 | 0.0003 | 0.0016 | 0.0012 | 75.78 |
| | Peak Height | 0.0081 | 0.0076 | 0.0086 | 0.0081 | 0.0005 | 6.17 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 5 | BlnkCorr Signal | 0.0018 | 0.0019 | -0.0009 | 0.0009 | 0.0016 | 170.20 |
| | Peak Area | 0.0018 | 0.0019 | -0.0009 | 0.0009 | 0.0016 | 170.20 |
| | Peak Height | 0.0066 | 0.0075 | 0.0062 | 0.0068 | 0.0007 | 9.84 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day2** hr 7.5 | BlnkCorr Signal | 0.0010 | 0.0029 | 0.0015 | 0.0018 | 0.0010 | 54.72 |
| | Peak Area | 0.0010 | 0.0029 | 0.0015 | 0.0018 | 0.0010 | 54.72 |
| | Peak Height | 0.0087 | 0.0070 | 0.0065 | 0.0074 | 0.0012 | 15.58 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 0 | BlnkCorr Signal | 0.0022 | 0.0009 | 0.0023 | 0.0018 | 0.0008 | 43.39 |
| | Peak Area | 0.0022 | 0.0009 | 0.0023 | 0.0018 | 0.0008 | 43.39 |
| | Peak Height | 0.0071 | 0.0068 | 0.0068 | 0.0069 | 0.0002 | 2.51 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 3.5 | BlnkCorr Signal | 0.0002 | 0.0006 | 0.0008 | 0.0005 | 0.0003 | 57.28 |
| | Peak Area | 0.0002 | 0.0006 | 0.0008 | 0.0005 | 0.0003 | 57.28 |
| | Peak Height | 0.0068 | 0.0058 | 0.0071 | 0.0066 | 0.0007 | 10.37 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day3** hr 7 | BlnkCorr Signal | -0.0016 | -0.0019 | -0.0010 | -0.0015 | 0.0005 | 30.55 |
| | Peak Area | -0.0016 | -0.0019 | -0.0010 | -0.0015 | 0.0005 | 30.55 |
| | Peak Height | 0.0074 | 0.0080 | 0.0099 | 0.0084 | 0.0013 | 15.48 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 0 | BlnkCorr Signal | 0.0002 | 0.0018 | 0.0017 | 0.0012 | 0.0009 | 72.67 |
| | Peak Area | 0.0002 | 0.0018 | 0.0017 | 0.0012 | 0.0009 | 72.67 |
| | Peak Height | 0.0085 | 0.0105 | 0.0088 | 0.0093 | 0.0011 | 11.64 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 7 | BlnkCorr Signal | 0.0006 | 0.0011 | 0.0011 | 0.0009 | 0.0003 | 30.93 |
| | Peak Area | 0.0006 | 0.0011 | 0.0011 | 0.0009 | 0.0003 | 30.93 |
| | Peak Height | 0.0084 | 0.0058 | 0.0068 | 0.0070 | 0.0013 | 18.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 | BlnkCorr Signal | | 0.0007 | 0.0025 | -0.0005 | 0.0009 | 0.0015 | 167.77 |
| | Peak Area | | 0.0007 | 0.0025 | -0.0005 | 0.0009 | 0.0015 | 167.77 |
| | Peak Height | | 0.0073 | 0.0075 | 0.0055 | 0.0068 | 0.0011 | 16.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 R | BlnkCorr Signal | | 0.0002 | 0.0001 | -0.0020 | -0.0006 | 0.0012 | 219.23 |
| | Peak Area | | 0.0002 | 0.0001 | -0.0020 | -0.0006 | 0.0012 | 219.23 |
| | Peak Height | | 0.0076 | 0.0076 | 0.0063 | 0.0072 | 0.0008 | 10.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RR | BlnkCorr Signal | | -0.0071 | -0.0026 | -0.0072 | -0.0056 | 0.0026 | 46.64 |
| | Peak Area | | -0.0071 | -0.0026 | -0.0072 | -0.0056 | 0.0026 | 46.64 |
| | Peak Height | | 0.0092 | 0.0082 | 0.0056 | 0.0077 | 0.0019 | 24.24 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day4** hr 10.5 RRR | BlnkCorr Signal | | -0.0043 | -0.0032 | -0.0045 | -0.0040 | 0.0007 | 17.50 |
| | Peak Area | | -0.0043 | -0.0032 | -0.0045 | -0.0040 | 0.0007 | 17.50 |
| | Peak Height | | 0.0076 | 0.0069 | 0.0085 | 0.0077 | 0.0008 | 10.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 0 | BlnkCorr Signal | | -0.0005 | 0.0008 | 0.0003 | 0.0002 | 0.0007 | 327.87 |
| | Peak Area | | -0.0005 | 0.0008 | 0.0003 | 0.0002 | 0.0007 | 327.87 |
| | Peak Height | | 0.0067 | 0.0073 | 0.0082 | 0.0074 | 0.0008 | 10.20 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day7** hr 7 | BlnkCorr Signal | | 0.0014 | 0.0016 | 0.0020 | 0.0017 | 0.0003 | 18.33 |
| | Peak Area | | 0.0014 | 0.0016 | 0.0020 | 0.0017 | 0.0003 | 18.33 |
| | Peak Height | | 0.0084 | 0.0084 | 0.0079 | 0.0082 | 0.0003 | 3.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | -0.0001 | -0.0003 | 0.0012 | 0.0003 | 0.0008 | 305.42 |
| | Peak Area | | -0.0001 | -0.0003 | 0.0012 | 0.0003 | 0.0008 | 305.42 |
| | Peak Height | | 0.0087 | 0.0065 | 0.0076 | 0.0076 | 0.0011 | 14.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 14.15% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.0052 | 0.0003 | 0.0025 | 0.0027 | 0.0025 | 92.03 |
| | Peak Area | | 0.0052 | 0.0003 | 0.0025 | 0.0027 | 0.0025 | 92.03 |
| | Peak Height | | 0.0082 | 0.0076 | 0.0099 | 0.0086 | 0.0012 | 13.93 |

## 23.3% aqua regia sample raw data

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 | BlnkCorr Signal | | 0.0024 | -0.0015 | -0.0002 | 0.0002 | 0.0020 | 851.05 |
| | Peak Area | | 0.0024 | -0.0015 | -0.0002 | 0.0002 | 0.0020 | 851.05 |
| | Peak Height | | 0.0084 | 0.0070 | 0.0066 | 0.0073 | 0.0009 | 12.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 1 R | BlnkCorr Signal | | -0.0019 | 0.0000 | 0.0016 | -0.0001 | 0.0018 | >999.9 |
| | Peak Area | | -0.0019 | 0.0000 | 0.0016 | -0.0001 | 0.0018 | >999.9 |
| | Peak Height | | 0.0084 | 0.0081 | 0.0083 | 0.0083 | 0.0002 | 1.85 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 2 | BlnkCorr Signal | | -0.0005 | -0.0018 | -0.0004 | -0.0009 | 0.0008 | 86.78 |
| | Peak Area | | -0.0005 | -0.0018 | -0.0004 | -0.0009 | 0.0008 | 86.78 |
| | Peak Height | | 0.0093 | 0.0084 | 0.0080 | 0.0086 | 0.0007 | 7.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 3 | BlnkCorr Signal | | -0.0006 | -0.0030 | 0.0006 | -0.0010 | 0.0018 | 183.30 |
| | Peak Area | | -0.0006 | -0.0030 | 0.0006 | -0.0010 | 0.0018 | 183.30 |
| | Peak Height | | 0.0077 | 0.0070 | 0.0091 | 0.0079 | 0.0011 | 13.48 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 4 | BlnkCorr Signal | | -0.0004 | -0.0024 | -0.0010 | -0.0013 | 0.0010 | 81.03 |
| | Peak Area | | -0.0004 | -0.0024 | -0.0010 | -0.0013 | 0.0010 | 81.03 |
| | Peak Height | | 0.0083 | 0.0091 | 0.0068 | 0.0081 | 0.0012 | 14.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 5 | BlnkCorr Signal | | 0.0000 | -0.0013 | 0.0019 | 0.0002 | 0.0016 | 804.67 |
| | Peak Area | | 0.0000 | -0.0013 | 0.0019 | 0.0002 | 0.0016 | 804.67 |
| | Peak Height | | 0.0068 | 0.0072 | 0.0079 | 0.0073 | 0.0006 | 7.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day1** hr 6 | BlnkCorr Signal | | -0.0013 | -0.0015 | -0.0045 | -0.0024 | 0.0018 | 73.67 |
| | Peak Area | | -0.0013 | -0.0015 | -0.0045 | -0.0024 | 0.0018 | 73.67 |
| | Peak Height | | 0.0079 | 0.0071 | 0.0072 | 0.0074 | 0.0004 | 5.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 0 | BlnkCorr Signal | | -0.0019 | -0.0012 | -0.0013 | -0.0015 | 0.0004 | 25.81 |
| | Peak Area | | -0.0019 | -0.0012 | -0.0013 | -0.0015 | 0.0004 | 25.81 |
| | Peak Height | | 0.0065 | 0.0069 | 0.0101 | 0.0078 | 0.0020 | 25.19 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 2.5 | BlnkCorr Signal | | -0.0008 | 0.0030 | -0.0016 | 0.0002 | 0.0025 | >999.9 |
| | Peak Area | | -0.0008 | 0.0030 | -0.0016 | 0.0002 | 0.0025 | >999.9 |
| | Peak Height | | 0.0080 | 0.0079 | 0.0089 | 0.0083 | 0.0006 | 6.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 5 | BlnkCorr Signal | | -0.0015 | -0.0015 | -0.0043 | -0.0024 | 0.0016 | 66.43 |
| | Peak Area | | -0.0015 | -0.0015 | -0.0043 | -0.0024 | 0.0016 | 66.43 |
| | Peak Height | | 0.0070 | 0.0078 | 0.0092 | 0.0080 | 0.0011 | 13.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day2** hr 7.5 | BlnkCorr Signal | | -0.0029 | -0.0014 | -0.0027 | -0.0023 | 0.0008 | 34.91 |
| | Peak Area | | -0.0029 | -0.0014 | -0.0027 | -0.0023 | 0.0008 | 34.91 |
| | Peak Height | | 0.0067 | 0.0082 | 0.0062 | 0.0070 | 0.0010 | 14.80 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 0 | BlnkCorr Signal | | -0.0010 | -0.0017 | -0.0031 | -0.0019 | 0.0011 | 55.31 |
| | Peak Area | | -0.0010 | -0.0017 | -0.0031 | -0.0019 | 0.0011 | 55.31 |
| | Peak Height | | 0.0100 | 0.0093 | 0.0073 | 0.0089 | 0.0014 | 15.80 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 3.5 | BlnkCorr Signal | | -0.0008 | -0.0017 | -0.0024 | -0.0016 | 0.0008 | 49.11 |
| | Peak Area | | -0.0008 | -0.0017 | -0.0024 | -0.0016 | 0.0008 | 49.11 |
| | Peak Height | | 0.0082 | 0.0112 | 0.0074 | 0.0089 | 0.0020 | 22.43 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day3** hr 7 | BlnkCorr Signal | | -0.0021 | -0.0007 | -0.0021 | -0.0016 | 0.0008 | 49.49 |
| | Peak Area | | -0.0021 | -0.0007 | -0.0021 | -0.0016 | 0.0008 | 49.49 |
| | Peak Height | | 0.0080 | 0.0070 | 0.0076 | 0.0075 | 0.0005 | 6.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 0 | BlnkCorr Signal | | -0.0020 | -0.0011 | -0.0006 | -0.0012 | 0.0007 | 57.52 |
| | Peak Area | | -0.0020 | -0.0011 | -0.0006 | -0.0012 | 0.0007 | 57.52 |
| | Peak Height | | 0.0098 | 0.0086 | 0.0085 | 0.0090 | 0.0007 | 8.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 7 | BlnkCorr Signal | | -0.0036 | -0.0011 | -0.0028 | -0.0025 | 0.0013 | 51.07 |
| | Peak Area | | -0.0036 | -0.0011 | -0.0028 | -0.0025 | 0.0013 | 51.07 |
| | Peak Height | | 0.0067 | 0.0114 | 0.0078 | 0.0086 | 0.0025 | 28.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 | BlnkCorr Signal | | -0.0021 | -0.0040 | -0.0025 | -0.0029 | 0.0010 | 34.94 |
| | Peak Area | | -0.0021 | -0.0040 | -0.0025 | -0.0029 | 0.0010 | 34.94 |
| | Peak Height | | 0.0079 | 0.0058 | 0.0097 | 0.0078 | 0.0020 | 25.02 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day4** hr 10.5 R | BlnkCorr Signal | | -0.0036 | -0.0021 | -0.0006 | -0.0021 | 0.0015 | 71.43 |
| | Peak Area | | -0.0036 | -0.0021 | -0.0006 | -0.0021 | 0.0015 | 71.43 |
| | Peak Height | | 0.0098 | 0.0079 | 0.0111 | 0.0096 | 0.0016 | 16.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 0 | BlnkCorr Signal | | -0.0023 | -0.0023 | -0.0033 | -0.0026 | 0.0006 | 21.92 |
| | Peak Area | | -0.0023 | -0.0023 | -0.0033 | -0.0026 | 0.0006 | 21.92 |
| | Peak Height | | 0.0099 | 0.0103 | 0.0071 | 0.0091 | 0.0017 | 19.16 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day7** hr 7 | BlnkCorr Signal | | -0.0021 | -0.0022 | -0.0017 | -0.0020 | 0.0003 | 13.23 |
| | Peak Area | | -0.0021 | -0.0022 | -0.0017 | -0.0020 | 0.0003 | 13.23 |
| | Peak Height | | 0.0084 | 0.0095 | 0.0091 | 0.0090 | 0.0006 | 6.19 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 (**168hrs**) | BlnkCorr Signal | | -0.0015 | -0.0050 | -0.0054 | -0.0040 | 0.0021 | 54.09 |
| | Peak Area | | -0.0015 | -0.0050 | -0.0054 | -0.0040 | 0.0021 | 54.09 |
| | Peak Height | | 0.0091 | 0.0087 | 0.0066 | 0.0081 | 0.0013 | 16.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| 23.3% **Day8** hr 0 R (**168hrs**) | BlnkCorr Signal | | 0.0012 | -0.0016 | -0.0017 | -0.0007 | 0.0016 | 235.17 |
| | Peak Area | | 0.0012 | -0.0016 | -0.0017 | -0.0007 | 0.0016 | 235.17 |
| | Peak Height | | 0.0086 | 0.0069 | 0.0092 | 0.0082 | 0.0012 | 14.49 |

## 7.10.3. Appendix 10c - Titanium Temperature raw data

**5% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 21.00 |
| | 2 | 20.50 |
| | 3 | 20.75 |
| | 4 | 20.75 |
| | 5 | 20.75 |
| | 6 | 20.75 |
| 2 | 24 | 20.75 |
| | 26.5 | 21.00 |
| | 29 | 21.50 |
| | 31.5 | 21.50 |
| 3 | 48 | 21.00 |
| | 51.5 | 21.25 |
| | 55 | 21.50 |
| 4 | 72 | 20.75 |
| | 79 | 20.75 |
| | **84.5** | 19.75 |
| 7 | 144 | 18.50 |
| | 151 | 19.00 |
| 8 | **168** | 19.00 |

**14.15% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 21.00 |
| | 2 | 20.50 |
| | 3 | 20.50 |
| | 4 | 20.50 |
| | 5 | 20.50 |
| | 6 | 20.50 |
| 2 | 24 | 20.75 |
| | 26.5 | 21.00 |
| | 29 | 21.25 |
| | 31.5 | 21.25 |
| 3 | 48 | 20.75 |
| | 51.5 | 21.25 |
| | 55 | 21.50 |
| 4 | 72 | 20.50 |
| | 79 | 20.50 |
| | **84.5** | 19.50 |
| 7 | 144 | 18.50 |
| | 151 | 19.00 |
| 8 | **168** | 19.00 |

**23.3% Aqua Regia Temperature data**

| Day | Hours | Temperature (°C) |
|---|---|---|
| 1 | **1** | 19.50 |
| | 2 | 19.50 |
| | 3 | 19.75 |
| | 4 | 20.00 |
| | 5 | 20.50 |
| | 6 | 21.00 |
| 2 | 24 | 21.00 |
| | 26.5 | 22.00 |
| | 29 | 22.00 |
| | 31.5 | 21.75 |

| Day | Hours | Temperature (°C) |
|---|---|---|
| 3 | 48 | 21.00 |
| | 51.5 | 22.00 |
| | 55 | 22.00 |
| 4 | 72 | 21.00 |
| | 79 | 21.25 |
| | **84.5** | 20.50 |
| 7 | 144 | 19.25 |
| | 151 | 19.75 |
| 8 | **168** | 20.00 |

### 7.11. Appendix 11 - Start and End weights of Individual metals

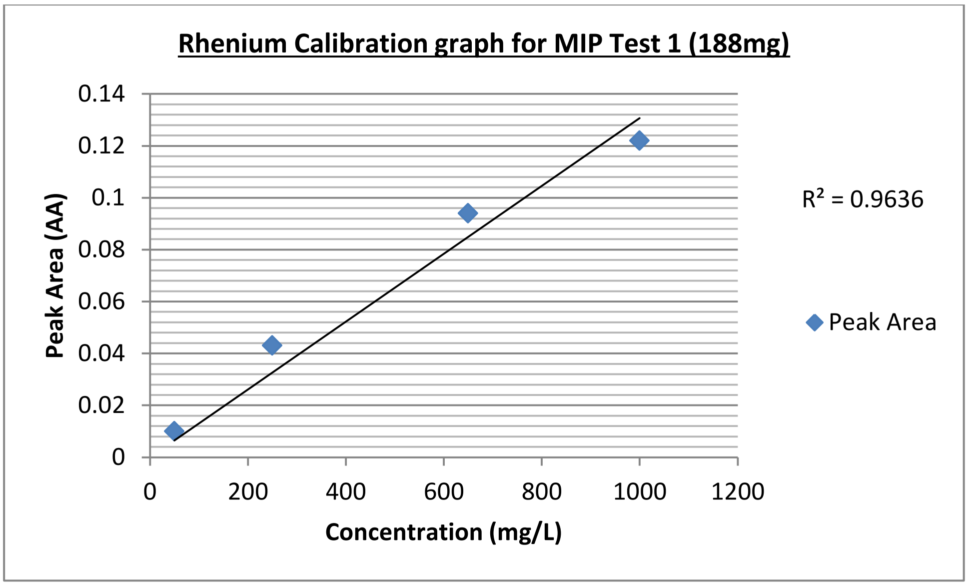
| | 23.3% aqua regia | | 14.15% aqua regia | | 5% aqua regia | |
|---|---|---|---|---|---|---|
| **Element** | start weight (g) | end weight (g) | start weight (g) | end weight (g) | start weight (g) | end weight (g) |
| Nickel | 26.06 | 4.8351 | 25.99 | 16.5995 | 21.64 | 19.9505 |
| Cobalt | 20.1386 | 2.8564 | 18.3535 | 15.5666 | 17.5141 | 16.1611 |
| Chromium | 21.8076 | 18.2778 | 21.5317 | 21.529 | 20.4178 | 20.4159 |
| Molybdenum | 4.0671 | 0 | 3.9725 | 0.1637 | 3.8222 | 3.7234 |
| Aluminium | - | - | - | - | 15.2514 | 14.2341 |
| Tungsten | 3.8183 | 3.7874 | 3.5788 | 3.5719 | 3.5447 | 3.542 |
| Rhenium | - | - | 4.1959 | 0 | 4.3022 | 4.1959 |
| Rhenium U.S | - | - | 0.2541 | 0 | 6.5643 | 0 |
| Titanium | 12.1805 | 12.1802 | 12.1919 | 12.1918 | 12.1752 | 12.1752 |
| Hafnium | 3.471 | 3.471 | 3.471 | 3.471 | 3.4712 | 3.471 |
| Tantalum | 26.9488 | 26.9487 | 26.9488 | 26.9488 | 26.9488 | 26.9488 |
| Super Alloy | 3.6186 | 1.9031 | - | - | - | - |

### 7.12. Appendix 12 - MIP Test 1 Calibration graph; XRF and AAS raw data

**Calibration graph data - MIP Test 1**

range: 50 - 1000ppm (mg/L

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| blank | 1.371 | 1.371 | 0.00100 | 0.07 |
| | 1.372 | | | |
| | 1.370 | | | |
| 50 | 0.009 | 0.010 | 0.00100 | 10.00 |
| | 0.010 | | | |
| | 0.011 | | | |
| 250 | 0.044 | 0.043 | 0.00115 | 2.69 |
| | 0.042 | | | |
| | 0.042 | | | |
| 650 | 0.093 | 0.093 | 0.00153 | 1.64 |
| | 0.091 | | | |
| | 0.094 | | | |
| 1000 | 0.122 | 0.122 | 0.00153 | 1.25 |
| | 0.123 | | | |
| | 0.120 | | | |




## AAS raw data - MIP Test 1

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 A.R Template | BlnkCorr Signal | | -0.014 | -0.013 | -0.013 | -0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | -63.13 | -57.15 | -59.06 | -59.78 | 3.0543 | 5.11 |
| | Stnd Conc (mg/L) | | -63.13 | -57.15 | -59.06 | -59.78 | 3.0543 | 5.11 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 1M1 Template | BlnkCorr Signal | | -0.018 | -0.018 | -0.020 | -0.019 | 0.0012 | 6.08 |
| | sample conc (mg/L) | | -81.68 | -82.46 | -88.30 | -84.15 | 3.6180 | 4.30 |
| | Stnd Conc (mg/L) | | -81.68 | -82.46 | -88.30 | -84.15 | 3.6180 | 4.30 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 1M2 Template | BlnkCorr Signal | | -0.022 | -0.022 | -0.022 | -0.022 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | -96.47 | -98.55 | -97.49 | -97.50 | 1.0401 | 1.07 |
| | Stnd Conc (mg/L) | | -96.47 | -98.55 | -97.49 | -97.50 | 1.0401 | 1.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 1M3 Template | BlnkCorr Signal | | -0.024 | -0.024 | -0.026 | -0.025 | 0.0012 | 4.62 |
| | sample conc (mg/L) | | -104.60 | -103.90 | -112.00 | -106.80 | 4.4881 | 4.20 |
| | Stnd Conc (mg/L) | | -104.60 | -103.90 | -112.00 | -106.80 | 4.4881 | 4.20 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 1M4 Template | BlnkCorr Signal | | -0.024 | -0.024 | -0.024 | -0.024 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | -105.40 | -104.60 | -105.00 | -105.00 | 0.4000 | 0.38 |
| | Stnd Conc (mg/L) | | -105.40 | -104.60 | -105.00 | -105.00 | 0.4000 | 0.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 1M5 Template | BlnkCorr Signal | | -0.031 | -0.032 | -0.032 | -0.032 | 0.0006 | 1.80 |
| | sample conc (mg/L) | | -130.70 | -135.10 | -135.40 | -133.80 | 2.6312 | 1.97 |
| | Stnd Conc (mg/L) | | -130.70 | -135.10 | -135.40 | -133.80 | 2.6312 | 1.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M1 Template | BlnkCorr Signal | | -0.028 | -0.029 | -0.028 | -0.028 | 0.0006 | 2.06 |
| | sample conc (mg/L) | | -118.80 | -124.50 | -121.80 | -121.70 | 2.8513 | 2.34 |
| | Stnd Conc (mg/L) | | -118.80 | -124.50 | -121.80 | -121.70 | 2.8513 | 2.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M2 Template | BlnkCorr Signal | | 0.007 | 0.008 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 35.30 | 38.29 | 38.58 | 37.39 | 1.8158 | 4.86 |
| | Stnd Conc (mg/L) | | 35.30 | 38.29 | 38.58 | 37.39 | 1.8158 | 4.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M3 Template | BlnkCorr Signal | | -0.003 | -0.004 | -0.003 | -0.003 | 0.0006 | 19.25 |
| | sample conc (mg/L) | | -14.69 | -18.43 | -13.29 | -15.47 | 2.6573 | 17.18 |
| | Stnd Conc (mg/L) | | -14.69 | -18.43 | -13.29 | -15.47 | 2.6573 | 17.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M4 Template | BlnkCorr Signal | | 0.008 | 0.008 | 0.009 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 36.75 | 35.45 | 41.18 | 37.79 | 3.0041 | 7.95 |
| | Stnd Conc (mg/L) | | 36.75 | 35.45 | 41.18 | 37.79 | 3.0041 | 7.95 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M5 Template | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 59.08 | 59.82 | 62.52 | 60.48 | 1.8107 | 2.99 |
| | Stnd Conc (mg/L) | | 59.08 | 59.82 | 62.52 | 60.48 | 1.8107 | 2.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M6 Template | BlnkCorr Signal | | 0.018 | 0.018 | 0.017 | 0.018 | 0.0006 | 3.21 |
| | sample conc (mg/L) | | 86.23 | 84.80 | 82.65 | 84.56 | 1.8020 | 2.13 |
| | Stnd Conc (mg/L) | | 86.23 | 84.80 | 82.65 | 84.56 | 1.8020 | 2.13 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M7 Template | BlnkCorr Signal | | 0.020 | 0.022 | 0.021 | 0.021 | 0.0010 | 4.76 |
| | sample conc (mg/L) | | 99.12 | 107.50 | 102.90 | 103.20 | 4.1967 | 4.07 |
| | Stnd Conc (mg/L) | | 99.12 | 107.50 | 102.90 | 103.20 | 4.1967 | 4.07 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3M8 Template | BlnkCorr Signal | | 0.023 | 0.022 | 0.022 | 0.022 | 0.0006 | 2.62 |
| | sample conc (mg/L) | | 111.20 | 107.30 | 107.60 | 108.70 | 2.1703 | 2.00 |
| | Stnd Conc (mg/L) | | 111.20 | 107.30 | 107.60 | 108.70 | 2.1703 | 2.00 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M1 Template | BlnkCorr Signal | | 0.022 | 0.022 | 0.022 | 0.022 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 105.90 | 106.00 | 108.80 | 106.90 | 1.6462 | 1.54 |
| | Stnd Conc (mg/L) | | 105.90 | 106.00 | 108.80 | 106.90 | 1.6462 | 1.54 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M2 Template | BlnkCorr Signal | | 0.020 | 0.019 | 0.020 | 0.020 | 0.0006 | 2.89 |
| | sample conc (mg/L) | | 97.27 | 91.57 | 94.43 | 94.42 | 2.8500 | 3.02 |
| | Stnd Conc (mg/L) | | 97.27 | 91.57 | 94.43 | 94.42 | 2.8500 | 3.02 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M3 Template | BlnkCorr Signal | | 0.019 | 0.019 | 0.019 | 0.019 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 89.10 | 90.92 | 93.05 | 91.02 | 1.9770 | 2.17 |
| | Stnd Conc (mg/L) | | 89.10 | 90.92 | 93.05 | 91.02 | 1.9770 | 2.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M4 Template | BlnkCorr Signal | | 0.014 | 0.015 | 0.015 | 0.015 | 0.0006 | 3.85 |
| | sample conc (mg/L) | | 80.04 | 88.06 | 87.27 | 85.13 | 4.4200 | 5.19 |
| | Stnd Conc (mg/L) | | 80.04 | 88.06 | 87.27 | 85.13 | 4.4200 | 5.19 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M5 Template | BlnkCorr Signal | | 0.020 | 0.019 | 0.020 | 0.020 | 0.0006 | 2.89 |
| | sample conc (mg/L) | | 118.20 | 115.40 | 119.60 | 117.80 | 2.1385 | 1.82 |
| | Stnd Conc (mg/L) | | 118.20 | 115.40 | 119.60 | 117.80 | 2.1385 | 1.82 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M6 Template | BlnkCorr Signal | | 0.025 | 0.024 | 0.024 | 0.024 | 0.0006 | 2.41 |
| | sample conc (mg/L) | | 149.20 | 147.50 | 146.30 | 147.60 | 1.4572 | 0.99 |
| | Stnd Conc (mg/L) | | 149.20 | 147.50 | 146.30 | 147.60 | 1.4572 | 0.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M7 Template | BlnkCorr Signal | | 0.026 | 0.027 | 0.027 | 0.027 | 0.0006 | 2.14 |
| | sample conc (mg/L) | | 158.50 | 162.70 | 165.00 | 162.10 | 3.2960 | 2.03 |
| | Stnd Conc (mg/L) | | 158.50 | 162.70 | 165.00 | 162.10 | 3.2960 | 2.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 6M8 Template | BlnkCorr Signal | | 0.028 | 0.028 | 0.028 | 0.028 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 172.80 | 171.50 | 171.80 | 172.00 | 0.6807 | 0.40 |
| | Stnd Conc (mg/L) | | 172.80 | 171.50 | 171.80 | 172.00 | 0.6807 | 0.40 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M1 Template | BlnkCorr Signal | | 0.029 | 0.028 | 0.028 | 0.028 | 0.0006 | 2.06 |
| | sample conc (mg/L) | | 177.60 | 172.70 | 171.70 | 174.00 | 3.1575 | 1.81 |
| | Stnd Conc (mg/L) | | 177.60 | 172.70 | 171.70 | 174.00 | 3.1575 | 1.81 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M2 Template | BlnkCorr Signal | | 0.028 | 0.028 | 0.028 | 0.028 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 172.20 | 168.10 | 168.80 | 169.70 | 2.1932 | 1.29 |
| | Stnd Conc (mg/L) | | 172.20 | 168.10 | 168.80 | 169.70 | 2.1932 | 1.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M3 Template | BlnkCorr Signal | | 0.027 | 0.028 | 0.027 | 0.027 | 0.0006 | 2.14 |
| | sample conc (mg/L) | | 163.60 | 169.80 | 167.60 | 167.00 | 3.1432 | 1.88 |
| | Stnd Conc (mg/L) | | 163.60 | 169.80 | 167.60 | 167.00 | 3.1432 | 1.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M4 Template | BlnkCorr Signal | | 0.026 | 0.025 | 0.026 | 0.026 | 0.0006 | 2.22 |
| | sample conc (mg/L) | | 158.90 | 153.90 | 157.70 | 156.80 | 2.6102 | 1.66 |
| | Stnd Conc (mg/L) | | 158.90 | 153.90 | 157.70 | 156.80 | 2.6102 | 1.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M5 Template | BlnkCorr Signal | | 0.024 | 0.025 | 0.024 | 0.024 | 0.0006 | 2.41 |
| | sample conc (mg/L) | | 144.10 | 149.20 | 144.00 | 145.70 | 2.9738 | 2.04 |
| | Stnd Conc (mg/L) | | 144.10 | 149.20 | 144.00 | 145.70 | 2.9738 | 2.04 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M6 Template | BlnkCorr Signal | | 0.010 | 0.012 | 0.011 | 0.011 | 0.0010 | 9.09 |
| | sample conc (mg/L) | | 74.56 | 78.35 | 76.01 | 76.34 | 1.9123 | 2.51 |
| | Stnd Conc (mg/L) | | 74.56 | 78.35 | 76.01 | 76.34 | 1.9123 | 2.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M7 Template | BlnkCorr Signal | | 0.012 | 0.013 | 0.012 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 82.56 | 90.65 | 86.10 | 86.44 | 4.0555 | 4.69 |
| | Stnd Conc (mg/L) | | 82.56 | 90.65 | 86.10 | 86.44 | 4.0555 | 4.69 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 8M8 Template | BlnkCorr Signal | | 0.014 | 0.014 | 0.014 | 0.014 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 93.75 | 97.24 | 95.12 | 95.37 | 1.7584 | 1.84 |
| | Stnd Conc (mg/L) | | 93.75 | 97.24 | 95.12 | 95.37 | 1.7584 | 1.84 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 3g/L ReAn1 | BlnkCorr Signal | | 0.015 | 0.014 | 0.014 | 0.014 | 0.0006 | 4.12 |
| | sample conc (mg/L) | | 102.00 | 99.57 | 101.40 | 101.00 | 1.2658 | 1.25 |
| | Stnd Conc (mg/L) | | 102.00 | 99.57 | 101.40 | 101.00 | 1.2658 | 1.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 Wash 1 ReAn1 | BlnkCorr Signal | | 0.012 | 0.014 | 0.013 | 0.013 | 0.0010 | 7.69 |
| | sample conc (mg/L) | | 86.99 | 96.87 | 93.61 | 92.49 | 5.0343 | 5.44 |
| | Stnd Conc (mg/L) | | 86.99 | 96.87 | 93.61 | 92.49 | 5.0343 | 5.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 Wash 2 ReAn1 | BlnkCorr Signal | | 0.012 | 0.013 | 0.013 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 81.54 | 88.35 | 87.86 | 85.92 | 3.7982 | 4.42 |
| | Stnd Conc (mg/L) | | 81.54 | 88.35 | 87.86 | 85.92 | 3.7982 | 4.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T1 Wash 3 ReAn1 | BlnkCorr Signal | | 0.012 | 0.011 | 0.012 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 82.85 | 74.18 | 82.25 | 79.76 | 4.8417 | 6.07 |
| | Stnd Conc (mg/L) | | 82.85 | 74.18 | 82.25 | 79.76 | 4.8417 | 6.07 |

## <u>XRF raw data - MIP Test 1</u>

% to mg/L conversion

1% = 1g/100ml = 10g/1000ml = 10,000mg/1000ml = 10000mg/L

| ID | Element | XRF % | concentration (mg/L) |
|---|---|---|---|
| Before Rinse | Ta | 0.162 | 1620 |
| | Nb | 0.265 | 2650 |
| | Ti | 0.326 | 3260 |
| | Fe | 0.009 | 90 |
| | Bal | 98.78 | 987800 |
| | Mo | 0.04 | 400 |
| | Zr | 0.028 | 280 |
| | Si | 0.004 | 40 |
| | Bi | 0.003 | 30 |

| | | | |
|---|---|---|---|
| | **Re** | **0.26** | **2600** |
| | V | 0.28 | 2800 |
| After Rinse | Ta | 3.3 | 33000 |
| | Sn | 0.033 | 330 |
| | W | 1.81 | 18100 |
| | Ti | 0.748 | 7480 |
| | Mn | 0.015 | 150 |
| | Bal | 93.16 | 931600 |
| | Sb | 0.019 | 190 |
| | Pd | 0.025 | 250 |
| | Rb | 0.003 | 30 |
| | Bi | 0.026 | 260 |
| | As | 0.112 | 1120 |
| | Se | 0.11 | 1100 |
| | **Re** | **0.651** | **6510** |
| | Co | 0.03 | 300 |
| | V | 0.683 | 6830 |
| 1M1 | Ta | 0.109 | 1090 |
| | Nb | 0.324 | 3240 |
| | Sn | 0.006 | 60 |
| | Ti | 0.534 | 5340 |
| | Fe | 0.026 | 260 |
| | Bal | 98.75 | 987500 |
| | Sb | 0.005 | 50 |
| | Mo | 0.051 | 510 |
| | Zr | 0.035 | 350 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.013** | **130** |
| | V | 0.302 | 3020 |
| 1M2 | Ta | 0.105 | 1050 |
| | Nb | 0.303 | 3030 |
| | Sn | 0.006 | 60 |
| | Ti | 0.575 | 5750 |
| | Fe | 0.008 | 80 |
| | Bal | 98.72 | 987200 |
| | Sb | 0.003 | 30 |
| | Mo | 0.05 | 500 |
| | Zr | 0.035 | 350 |
| | Sr | 0.006 | 60 |
| | Bi | 0.004 | 40 |
| | **Re** | **0.032** | **320** |
| | V | 0.326 | 3260 |
| 1M3 | Ta | 0.085 | 850 |
| | Nb | 0.321 | 3210 |

| | | | |
|---|---|---|---|
| | Sn | 0.006 | 60 |
| | Ti | 0.499 | 4990 |
| | Fe | 0.017 | 170 |
| | Bal | 98.83 | 988300 |
| | Sb | 0.004 | 40 |
| | Mo | 0.051 | 510 |
| | Zr | 0.035 | 350 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.026** | **260** |
| | V | 0.283 | 2830 |
| 1M4 | Ta | 0.078 | 780 |
| | Nb | 0.306 | 3060 |
| | Sn | 0.005 | 50 |
| | Ti | 0.425 | 4250 |
| | Fe | 0.017 | 170 |
| | Bal | 98.88 | 988800 |
| | Sb | 0.004 | 40 |
| | Mo | 0.049 | 490 |
| | Zr | 0.034 | 340 |
| | Sr | 0.005 | 50 |
| | Rb | 0.002 | 20 |
| | Bi | 0.004 | 40 |
| | **Re** | **0.056** | **560** |
| | V | 0.284 | 2840 |
| 1M5 | Ta | 2.36 | 23600 |
| | Sn | 0.039 | 390 |
| | W | 1.92 | 19200 |
| | Ti | 0.795 | 7950 |
| | Mn | 0.037 | 370 |
| | Bal | 93.52 | 935200 |
| | Sb | 0.019 | 190 |
| | Cd | 0.034 | 340 |
| | Pd | 0.026 | 260 |
| | Sr | 0.002 | 20 |
| | Rb | 0.003 | 30 |
| | Bi | 0.031 | 310 |
| | As | 0.096 | 960 |
| | Se | 0.104 | 1040 |
| | **Re** | **0.899** | **8990** |
| | Co | 0.033 | 330 |
| | V | 0.699 | 6990 |
| 3M1 | Ta | 0.104 | 1040 |
| | Nb | 0.292 | 2920 |
| | Sn | 0.003 | 30 |

| | | | |
|---|---|---|---|
| | Ti | 0.501 | 5010 |
| | Bal | 98.8 | 988000 |
| | Sb | 0.004 | 40 |
| | Mo | 0.049 | 490 |
| | Zr | 0.033 | 330 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.05** | **500** |
| | V | 0.309 | 3090 |
| 3M2 | Ta | 0.087 | 870 |
| | Nb | 0.221 | 2210 |
| | Sn | 0.003 | 30 |
| | Ti | 0.251 | 2510 |
| | Bal | 99.14 | 991400 |
| | Mo | 0.032 | 320 |
| | Zr | 0.024 | 240 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.07** | **700** |
| | V | 0.281 | 2810 |
| 3M3 | Ta | 0.071 | 710 |
| | Nb | 0.234 | 2340 |
| | Sn | 0.003 | 30 |
| | Ti | 0.241 | 2410 |
| | Bal | 99.19 | 991900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.056** | **560** |
| | V | 0.259 | 2590 |
| 3M4 | Ta | 2.35 | 23500 |
| | Sn | 0.028 | 280 |
| | W | 1.59 | 15900 |
| | Ti | 0.897 | 8970 |
| | Mn | 0.024 | 240 |
| | Bal | 94.05 | 940500 |
| | Sb | 0.01 | 100 |
| | Pd | 0.026 | 260 |
| | Sr | 0.002 | 20 |
| | Rb | 0.002 | 20 |
| | Bi | 0.024 | 240 |
| | As | 0.082 | 820 |
| | Se | 0.081 | 810 |

| | | | |
|---|---|---|---|
| | **Re** | **0.609** | **6090** |
| | Co | 0.022 | 220 |
| | V | 0.786 | 7860 |
| 3M5 | Ta | 0.08 | 800 |
| | Nb | 0.258 | 2580 |
| | Sn | 0.004 | 40 |
| | Ti | 0.396 | 3960 |
| | Fe | 0.03 | 300 |
| | Bal | 98.92 | 989200 |
| | Sb | 0.003 | 30 |
| | Mo | 0.039 | 390 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.088** | **880** |
| | V | 0.3 | 3000 |
| 3M6 | Ta | 0.077 | 770 |
| | Nb | 0.244 | 2440 |
| | Sn | 0.005 | 50 |
| | Ti | 0.327 | 3270 |
| | Bal | 99.03 | 990300 |
| | Sb | 0.003 | 30 |
| | Mo | 0.038 | 380 |
| | Zr | 0.025 | 250 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.082** | **820** |
| | V | 0.293 | 2930 |
| 3M7 | Ta | 0.084 | 840 |
| | Nb | 0.229 | 2290 |
| | Sn | 0.003 | 30 |
| | Ti | 0.321 | 3210 |
| | Bal | 99.09 | 990900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.034 | 340 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.041** | **410** |
| | V | 0.286 | 2860 |
| 3M8 | Ta | 0.075 | 750 |
| | Nb | 0.244 | 2440 |
| | Sn | 0.003 | 30 |
| | Ti | 0.323 | 3230 |
| | Bal | 99.06 | 990600 |

| | | | |
|---|---|---|---|
| | Sb | 0.002 | 20 |
| | Mo | 0.035 | 350 |
| | Zr | 0.023 | 230 |
| | Sr | 0.004 | 40 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.071** | **710** |
| | V | 0.282 | 2820 |
| 6M1 | Ta | 0.094 | 940 |
| | Nb | 0.245 | 2450 |
| | Sn | 0.005 | 50 |
| | Ti | 0.4 | 4000 |
| | Fe | 0.017 | 170 |
| | Bal | 98.96 | 989600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.036 | 360 |
| | Zr | 0.025 | 250 |
| | Sr | 0.04 | 400 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.066** | **660** |
| | V | 0.279 | 2790 |
| 6M2 | Ta | 0.082 | 820 |
| | Nb | 0.235 | 2350 |
| | Ti | 0.361 | 3610 |
| | Fe | 0.019 | 190 |
| | Bal | 98.99 | 989900 |
| | Mo | 0.034 | 340 |
| | Zr | 0.024 | 240 |
| | Sr | 0.004 | 40 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.062** | **620** |
| | V | 0.314 | 3140 |
| 6M3 | Ta | 0.092 | 920 |
| | Nb | 0.233 | 2330 |
| | Sn | 0.004 | 40 |
| | Ti | 0.347 | 3470 |
| | Bal | 99.02 | 990200 |
| | Sb | 0.003 | 30 |
| | Mo | 0.036 | 360 |
| | Zr | 0.024 | 240 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.058** | **580** |
| | V | 0.295 | 2950 |
| 6M4 | Ta | 2.44 | 24400 |
| | Sn | 0.036 | 360 |

| | | | |
|---|---|---|---|
| | W | 1.71 | 17100 |
| | Ti | 0.805 | 8050 |
| | Mn | 0.027 | 270 |
| | Bal | 93.87 | 938700 |
| | Sb | 0.014 | 140 |
| | Pd | 0.026 | 260 |
| | Sr | 0.003 | 30 |
| | Rb | 0.002 | 20 |
| | Bi | 0.026 | 260 |
| | As | 0.088 | 880 |
| | Se | 0.085 | 850 |
| | **Re** | **0.615** | **6150** |
| | Co | 0.027 | 270 |
| | V | 0.817 | 8170 |
| 6M5 | Ta | 0.088 | 880 |
| | Nb | 0.225 | 2250 |
| | Sn | 0.004 | 40 |
| | Ti | 0.297 | 2970 |
| | Fe | 0.009 | 90 |
| | Bal | 99.13 | 991300 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.049** | **490** |
| | V | 0.263 | 2630 |
| 6M6 | Ta | 0.077 | 770 |
| | Nb | 0.238 | 2380 |
| | Sn | 0.005 | 50 |
| | Ti | 0.285 | 2850 |
| | Bal | 99.14 | 991400 |
| | Sb | 0.004 | 40 |
| | Mo | 0.035 | 350 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.05** | **500** |
| | V | 0.26 | 2600 |
| 6M7 | Ta | 0.078 | 780 |
| | Nb | 0.226 | 2260 |
| | Sn | 0.003 | 30 |
| | Ti | 0.312 | 3120 |
| | Bal | 99.09 | 990900 |
| | Mo | 0.032 | 320 |

| | | | |
|---|---|---|---|
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.045** | **450** |
| | V | 0.296 | 2960 |
| 6M8 | Ta | 0.095 | 950 |
| | Nb | 0.228 | 2280 |
| | Sn | 0.004 | 40 |
| | Ti | 0.266 | 2660 |
| | Fe | 0.008 | 80 |
| | Bal | 99.17 | 991700 |
| | Sb | 0.003 | 30 |
| | Mo | 0.035 | 350 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Rb | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.045** | **450** |
| | V | 0.243 | 2430 |
| 8M1 | Ta | 0.069 | 690 |
| | Nb | 0.241 | 2410 |
| | Sn | 0.004 | 40 |
| | Ti | 0.0315 | 315 |
| | Fe | 0.016 | 160 |
| | Bal | 99.1 | 991000 |
| | Sb | 0.003 | 30 |
| | Mo | 0.036 | 360 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.045** | **450** |
| | V | 0.271 | 2710 |
| 8M2 | Ta | 0.072 | 720 |
| | Nb | 0.218 | 2180 |
| | Ti | 0.35 | 3500 |
| | Fe | 0.007 | 70 |
| | Bal | 99.12 | 991200 |
| | Sb | 0.003 | 30 |
| | Mo | 0.031 | 310 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.03** | **300** |
| | V | 0.255 | 2550 |
| 8M3 | Ta | 0.084 | 840 |

| | | | |
|---|---|---|---|
| | Nb | 0.227 | 2270 |
| | Sn | 0.004 | 40 |
| | Ti | 0.4 | 4000 |
| | Fe | 0.05 | 500 |
| | Bal | 99.02 | 990200 |
| | Sb | 0.004 | 40 |
| | Mo | 0.033 | 330 |
| | Zr | 0.023 | 230 |
| | Sr | 0.033 | 330 |
| | Rb | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.038** | **380** |
| | V | 0.259 | 2590 |
| 8M4 | Ta | 0.086 | 860 |
| | Nb | 0.216 | 2160 |
| | Ti | 0.318 | 3180 |
| | Fe | 0.018 | 180 |
| | Bal | 99.1 | 991000 |
| | Sb | 0.003 | 30 |
| | Mo | 0.033 | 330 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.036** | **360** |
| | V | 0.283 | 2830 |
| 8M5 | Ta | 0.07 | 700 |
| | Nb | 0.214 | 2140 |
| | Ti | 0.355 | 3550 |
| | Bal | 99.1 | 991000 |
| | Mo | 0.03 | 300 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.028** | **280** |
| | V | 0.288 | 2880 |
| 8M6 | Ta | 0.075 | 750 |
| | Nb | 0.219 | 2190 |
| | Sn | 0.004 | 40 |
| | Ti | 0.269 | 2690 |
| | Bal | 99.24 | 992400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |

| | | | |
|---|---|---|---|
| | **Re** | **0.031** | **310** |
| | V | 0.221 | 2210 |
| 8M7 | Ta | 0.076 | 760 |
| | Nb | 0.21 | 2100 |
| | Sn | 0.003 | 30 |
| | Ti | 0.25 | 2500 |
| | Bal | 99.24 | 992400 |
| | Mo | 0.028 | 280 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.029** | **290** |
| | V | 0.254 | 2540 |
| 8M8 | Ta | 0.082 | 820 |
| | Nb | 0.22 | 2200 |
| | Ti | 0.272 | 2720 |
| | Bal | 99.22 | 992200 |
| | Sb | 0.002 | 20 |
| | Mo | 0.03 | 300 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.025** | **250** |
| | V | 0.235 | 2350 |
| 3000mg/L $NH_4ReO_4$ analyte addition | Ta | 0.525 | 5250 |
| | Nb | 0.223 | 2230 |
| | Ti | 0.161 | 1610 |
| | Bal | 96.99 | 969900 |
| | Mo | 0.029 | 290 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.005 | 50 |
| | **Re** | **2.11** | **21100** |
| | Co | 0.005 | 50 |
| | V | 0.152 | 1520 |
| Wash 1 | Ta | 0.527 | 5270 |
| | Nb | 0.225 | 2250 |
| | Sn | 0.004 | 40 |
| | Ti | 0.167 | 1670 |
| | Fe | 96.93 | 969300 |
| | Bal | 0.003 | 30 |
| | Sb | 0.029 | 290 |
| | Mo | 0.024 | 240 |
| | Zr | 0.003 | 30 |

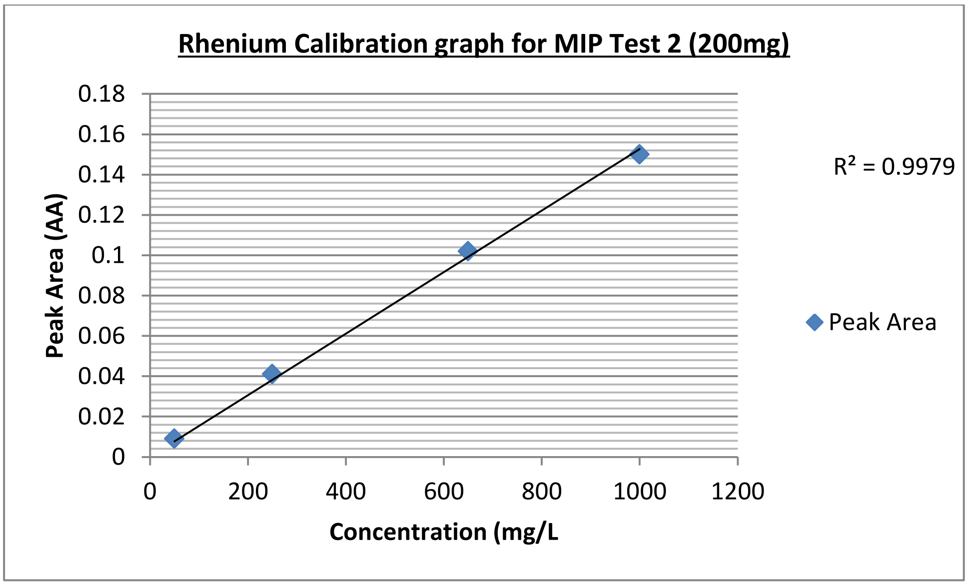
| | | | |
|---|---|---|---|
| | Sr | 0.003 | 30 |
| | Bi | 0.004 | 40 |
| | As | 0.002 | 20 |
| | **Re** | **2.16** | **21600** |
| | Co | 0.006 | 60 |
| | V | 0.151 | 1510 |
| Wash 2 | Ta | 0.557 | 5570 |
| | Nb | 0.209 | 2090 |
| | Ti | 0.192 | 1920 |
| | Bal | 96.72 | 967200 |
| | Mo | 0.024 | 240 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | As | 0.005 | 50 |
| | Se | 0.002 | 20 |
| | **Re** | **2.34** | **23400** |
| | Co | 0.006 | 60 |
| | V | 0.162 | 1620 |
| Wash 3 | Ta | 0.55 | 5500 |
| | Nb | 0.212 | 2120 |
| | Ti | 0.163 | 1630 |
| | Bal | 96.81 | 968100 |
| | Mo | 0.025 | 250 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.005 | 50 |
| | Se | 0.002 | 20 |
| | **Re** | **2.29** | **22900** |
| | Co | 0.007 | 70 |
| | V | 0.145 | 1450 |

## 7.13. Appendix 13 - MIP Test 2 Calibration graph; XRF and AAS raw data

**Calibration graph data - MIP Test 2**

range: 50 - 1000ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| blank | 0.486 | 0.486 | 0.00000 | 0.00 |
| | 0.486 | | | |
| | 0.486 | | | |
| 50 | 0.008 | 0.009 | 0.00058 | 6.42 |
| | 0.008 | | | |
| | 0.009 | | | |
| 250 | 0.041 | 0.041 | 0.00000 | 0.00 |
| | 0.041 | | | |
| | 0.041 | | | |
| 650 | 0.101 | 0.102 | 0.00058 | 0.57 |
| | 0.102 | | | |
| | 0.102 | | | |
| 1000 | 0.157 | 0.150 | 0.01012 | 6.74 |
| | 0.156 | | | |
| | 0.139 | | | |



## AAS raw data - MIP Test 2

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 A.R Template | BlnkCorr Signal | | -0.014 | -0.012 | -0.013 | -0.013 | 0.0010 | 7.69 |
| | sample conc (mg/L) | | -62.62 | -56.93 | -57.76 | -59.10 | 3.0737 | 5.20 |
| | Stnd Conc (mg/L) | | -62.62 | -56.93 | -57.76 | -59.10 | 3.0737 | 5.20 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 1M1 Template | BlnkCorr Signal | | -0.019 | -0.018 | -0.016 | -0.018 | 0.0015 | 8.49 |
| | sample conc (mg/L) | | -86.50 | -80.76 | -74.02 | -80.43 | 6.2467 | 7.77 |
| | Stnd Conc (mg/L) | | -86.50 | -80.76 | -74.02 | -80.43 | 6.2467 | 7.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 1M2 Template | BlnkCorr Signal | | -0.020 | -0.020 | -0.020 | -0.020 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | -90.06 | -89.04 | -90.58 | -89.89 | 0.7834 | 0.87 |
| | Stnd Conc (mg/L) | | -90.06 | -89.04 | -90.58 | -89.89 | 0.7834 | 0.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 1M3 Template | BlnkCorr Signal | | -0.023 | -0.023 | -0.023 | -0.023 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | -102.40 | -99.90 | -100.60 | -101.00 | 1.2897 | 1.28 |
| | Stnd Conc (mg/L) | | -102.40 | -99.90 | -100.60 | -101.00 | 1.2897 | 1.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 1M4 Template | BlnkCorr Signal | | -0.025 | -0.025 | -0.023 | -0.024 | 0.0012 | 4.81 |
| | sample conc (mg/L) | | -107.40 | -109.00 | -99.29 | -105.30 | 5.2060 | 4.94 |
| | Stnd Conc (mg/L) | | -107.40 | -109.00 | -99.29 | -105.30 | 5.2060 | 4.94 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 1M5 Template | BlnkCorr Signal | | -0.032 | -0.031 | -0.029 | -0.031 | 0.0015 | 4.93 |
| | sample conc (mg/L) | | -133.70 | -130.30 | -125.40 | -129.80 | 4.1725 | 3.21 |
| | Stnd Conc (mg/L) | | -133.70 | -130.30 | -125.40 | -129.80 | 4.1725 | 3.21 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M1 Template | BlnkCorr Signal | | -0.027 | -0.028 | -0.027 | -0.027 | 0.0006 | 2.14 |
| | sample conc (mg/L) | | -116.10 | -119.80 | -116.60 | -117.50 | 2.0075 | 1.71 |
| | Stnd Conc (mg/L) | | -116.10 | -119.80 | -116.60 | -117.50 | 2.0075 | 1.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M2 Template | BlnkCorr Signal | | 0.007 | 0.007 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 35.90 | 35.29 | 40.71 | 37.34 | 2.9689 | 7.95 |
| | Stnd Conc (mg/L) | | 35.90 | 35.29 | 40.71 | 37.34 | 2.9689 | 7.95 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M3 Template | BlnkCorr Signal | | -0.003 | -0.004 | -0.003 | -0.003 | 0.0006 | 19.25 |
| | sample conc (mg/L) | | -14.69 | -18.43 | -13.29 | -15.47 | 2.6573 | 17.18 |
| | Stnd Conc (mg/L) | | -14.69 | -18.43 | -13.29 | -15.47 | 2.6573 | 17.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M4 Template | BlnkCorr Signal | | 0.010 | 0.011 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 44.29 | 49.23 | 44.71 | 46.08 | 2.7389 | 5.94 |
| | Stnd Conc (mg/L) | | 44.29 | 49.23 | 44.71 | 46.08 | 2.7389 | 5.94 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M5 Template | BlnkCorr Signal | | 0.014 | 0.014 | 0.014 | 0.014 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 66.30 | 64.97 | 66.63 | 65.97 | 0.8788 | 1.33 |
| | Stnd Conc (mg/L) | | 66.30 | 64.97 | 66.63 | 65.97 | 0.8788 | 1.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M6 Template | BlnkCorr Signal | | 0.019 | 0.019 | 0.019 | 0.019 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 91.31 | 90.63 | 89.76 | 90.57 | 0.7769 | 0.86 |
| | Stnd Conc (mg/L) | | 91.31 | 90.63 | 89.76 | 90.57 | 0.7769 | 0.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M7 Template | BlnkCorr Signal | | 0.021 | 0.022 | 0.021 | 0.021 | 0.0006 | 2.75 |
| | sample conc (mg/L) | | 103.10 | 104.90 | 102.90 | 103.60 | 1.1015 | 1.06 |
| | Stnd Conc (mg/L) | | 103.10 | 104.90 | 102.90 | 103.60 | 1.1015 | 1.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3M8 Template | BlnkCorr Signal | | 0.024 | 0.022 | 0.022 | 0.023 | 0.0012 | 5.02 |
| | sample conc (mg/L) | | 117.00 | 107.80 | 110.20 | 111.70 | 4.7721 | 4.27 |
| | Stnd Conc (mg/L) | | 117.00 | 107.80 | 110.20 | 111.70 | 4.7721 | 4.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M1 Template | BlnkCorr Signal | | 0.021 | 0.021 | 0.021 | 0.021 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 103.50 | 101.60 | 100.10 | 101.70 | 1.7039 | 1.68 |
| | Stnd Conc (mg/L) | | 103.50 | 101.60 | 100.10 | 101.70 | 1.7039 | 1.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M2 Template | BlnkCorr Signal | | 0.020 | 0.018 | 0.018 | 0.019 | 0.0012 | 6.08 |
| | sample conc (mg/L) | | 95.53 | 87.11 | 84.40 | 89.01 | 5.8040 | 6.52 |
| | Stnd Conc (mg/L) | | 95.53 | 87.11 | 84.40 | 89.00 | 5.8040 | 6.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M3 Template | BlnkCorr Signal | | 0.018 | 0.019 | 0.018 | 0.018 | 0.0006 | 3.21 |
| | sample conc (mg/L) | | 85.72 | 89.93 | 85.97 | 87.21 | 2.3618 | 2.71 |
| | Stnd Conc (mg/L) | | 85.72 | 89.93 | 85.97 | 87.21 | 2.3618 | 2.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M4 Template | BlnkCorr Signal | | 0.015 | 0.015 | 0.015 | 0.015 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 90.38 | 91.16 | 90.27 | 90.60 | 0.4852 | 0.54 |
| | Stnd Conc (mg/L) | | 90.38 | 91.16 | 90.27 | 90.60 | 0.4852 | 0.54 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M5 Template | BlnkCorr Signal | | 0.021 | 0.022 | 0.021 | 0.021 | 0.0006 | 2.75 |
| | sample conc (mg/L) | | 126.20 | 131.20 | 126.00 | 127.80 | 2.9462 | 2.31 |
| | Stnd Conc (mg/L) | | 126.20 | 131.20 | 126.00 | 127.80 | 2.9462 | 2.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M6 Template | BlnkCorr Signal | | 0.026 | 0.026 | 0.025 | 0.026 | 0.0006 | 2.22 |
| | sample conc (mg/L) | | 155.70 | 157.30 | 152.90 | 155.30 | 2.2271 | 1.43 |
| | Stnd Conc (mg/L) | | 155.70 | 157.30 | 152.90 | 155.30 | 2.2271 | 1.43 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M7 Template | BlnkCorr Signal | | 0.027 | 0.027 | 0.027 | 0.027 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 164.40 | 166.60 | 167.60 | 166.20 | 1.6371 | 0.99 |
| | Stnd Conc (mg/L) | | 164.40 | 166.60 | 167.60 | 166.20 | 1.6371 | 0.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M8 Template | BlnkCorr Signal | | 0.028 | 0.028 | 0.028 | 0.028 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 174.20 | 174.20 | 170.90 | 173.10 | 1.9053 | 1.10 |
| | Stnd Conc (mg/L) | | 174.20 | 174.20 | 170.90 | 173.10 | 1.9053 | 1.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M1 Template | BlnkCorr Signal | | 0.028 | 0.029 | 0.027 | 0.028 | 0.0010 | 3.57 |
| | sample conc (mg/L) | | 168.50 | 180.60 | 167.30 | 172.20 | 7.3569 | 4.27 |
| | Stnd Conc (mg/L) | | 168.50 | 180.60 | 167.30 | 172.20 | 7.3569 | 4.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M2 Template | BlnkCorr Signal | | 0.028 | 0.028 | 0.028 | 0.028 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 170.80 | 170.60 | 171.60 | 171.00 | 0.5292 | 0.31 |
| | Stnd Conc (mg/L) | | 170.80 | 170.60 | 171.60 | 171.00 | 0.5292 | 0.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M3 Template | BlnkCorr Signal | | 0.027 | 0.027 | 0.027 | 0.027 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 166.10 | 166.50 | 161.50 | 164.70 | 2.7785 | 1.69 |
| | Stnd Conc (mg/L) | | 166.10 | 166.50 | 161.50 | 164.70 | 2.7785 | 1.69 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M4 Template | BlnkCorr Signal | | 0.025 | 0.026 | 0.026 | 0.026 | 0.0006 | 2.22 |
| | sample conc (mg/L) | | 154.50 | 155.50 | 157.40 | 155.80 | 1.4731 | 0.95 |
| | Stnd Conc (mg/L) | | 154.50 | 155.50 | 157.40 | 155.80 | 1.4731 | 0.95 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M5 Template | BlnkCorr Signal | | 0.024 | 0.024 | 0.031 | 0.026 | 0.0040 | 15.54 |
| | sample conc (mg/L) | | 145.60 | 145.20 | 189.50 | 160.10 | 25.4619 | 15.90 |
| | Stnd Conc (mg/L) | | 145.60 | 145.20 | 189.50 | 160.10 | 25.4619 | 15.90 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M6 Template | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 74.25 | 82.34 | 78.98 | 78.52 | 4.0643 | 5.18 |
| | Stnd Conc (mg/L) | | 74.25 | 82.34 | 78.98 | 78.52 | 4.0643 | 5.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M7 Template | BlnkCorr Signal | | 0.012 | 0.013 | 0.012 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 83.54 | 90.42 | 87.53 | 87.16 | 3.4546 | 3.96 |
| | Stnd Conc (mg/L) | | 83.54 | 90.42 | 87.53 | 87.16 | 3.4546 | 3.96 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M8 Template | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 98.42 | 99.89 | 99.10 | 99.14 | 0.7357 | 0.74 |
| | Stnd Conc (mg/L) | | 98.42 | 99.89 | 99.10 | 99.14 | 0.7357 | 0.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn | BlnkCorr Signal | | 0.014 | 0.015 | 0.013 | 0.014 | 0.0010 | 7.14 |
| | sample conc (mg/L) | | 94.83 | 101.40 | 93.00 | 96.42 | 4.4173 | 4.58 |
| | Stnd Conc (mg/L) | | 94.83 | 101.40 | 93.00 | 96.42 | 4.4173 | 4.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn | BlnkCorr Signal | | 0.013 | 0.013 | 0.014 | 0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | 93.47 | 87.29 | 94.88 | 91.88 | 4.0371 | 4.39 |
| | Stnd Conc (mg/L) | | 93.47 | 87.29 | 94.88 | 91.88 | 4.0371 | 4.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn | BlnkCorr Signal | | 0.012 | 0.012 | 0.013 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 81.41 | 82.95 | 88.44 | 84.27 | 3.6953 | 4.39 |
| | Stnd Conc (mg/L) | | 81.41 | 82.95 | 88.44 | 84.27 | 3.6953 | 4.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn | BlnkCorr Signal | | 0.010 | 0.012 | 0.011 | 0.011 | 0.0010 | 9.09 |
| | sample conc (mg/L) | | 72.10 | 80.20 | 78.27 | 76.86 | 4.2309 | 5.50 |
| | Stnd Conc (mg/L) | | 72.10 | 80.20 | 78.27 | 76.86 | 4.2309 | 5.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M1 ReAn | BlnkCorr Signal | | 0.006 | 0.006 | 0.007 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 39.97 | 39.98 | 40.83 | 40.26 | 0.4937 | 1.23 |
| | Stnd Conc (mg/L) | | 39.97 | 39.98 | 40.83 | 40.26 | 0.4937 | 1.23 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M2 ReAn | BlnkCorr Signal | | 0.009 | 0.008 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 53.15 | 50.18 | 52.96 | 52.10 | 1.6626 | 3.19 |
| | Stnd Conc (mg/L) | | 53.15 | 50.18 | 52.96 | 52.10 | 1.6626 | 3.19 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M3 ReAn | BlnkCorr Signal | | 0.008 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 52.08 | 55.65 | 55.51 | 54.42 | 2.0219 | 3.72 |
| | Stnd Conc (mg/L) | | 52.08 | 55.65 | 55.51 | 54.42 | 2.0219 | 3.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M4 ReAn | BlnkCorr Signal | | 0.008 | 0.007 | 0.008 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 46.76 | 42.42 | 50.24 | 46.47 | 3.9179 | 8.43 |
| | Stnd Conc (mg/L) | | 46.76 | 42.42 | 50.24 | 46.47 | 3.9179 | 8.43 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M5 ReAn | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 50.63 | 52.41 | 46.60 | 49.88 | 2.9767 | 5.97 |
| | Stnd Conc (mg/L) | | 50.63 | 52.41 | 46.60 | 49.88 | 2.9767 | 5.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M6 ReAn | BlnkCorr Signal | | 0.008 | 0.007 | 0.009 | 0.008 | 0.0010 | 12.50 |
| | sample conc (mg/L) | | 48.28 | 45.43 | 58.70 | 50.80 | 6.9856 | 13.75 |
| | Stnd Conc (mg/L) | | 48.28 | 45.43 | 58.70 | 50.80 | 6.9856 | 13.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M7 ReAn | BlnkCorr Signal | | 0.007 | 0.008 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 45.63 | 49.86 | 50.82 | 48.77 | 2.7614 | 5.66 |
| | Stnd Conc (mg/L) | | 45.63 | 49.86 | 50.82 | 48.77 | 2.7614 | 5.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M8 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 46.34 | 46.32 | 44.46 | 45.71 | 1.0797 | 2.36 |
| | Stnd Conc (mg/L) | | 46.34 | 46.32 | 44.46 | 45.71 | 1.0797 | 2.36 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M9 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 45.35 | 44.40 | 51.53 | 47.09 | 3.8715 | 8.22 |
| | Stnd Conc (mg/L) | | 45.35 | 44.40 | 51.53 | 47.09 | 3.8715 | 8.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M10 ReAn | BlnkCorr Signal | | 0.008 | 0.007 | 0.008 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 48.66 | 42.45 | 47.83 | 46.31 | 3.3714 | 7.28 |
| | Stnd Conc (mg/L) | | 48.66 | 42.45 | 47.83 | 46.31 | 3.3714 | 7.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M11 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 41.09 | 45.69 | 43.16 | 43.31 | 2.3038 | 5.32 |
| | Stnd Conc (mg/L) | | 41.09 | 45.69 | 43.16 | 43.31 | 2.3038 | 5.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M12 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.006 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 45.13 | 43.34 | 35.79 | 41.42 | 4.9572 | 11.97 |
| | Stnd Conc (mg/L) | | 45.13 | 43.34 | 35.79 | 41.42 | 4.9572 | 11.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M13 ReAn | BlnkCorr Signal | | 0.005 | 0.005 | 0.006 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 33.44 | 33.09 | 39.86 | 35.47 | 3.8116 | 10.75 |
| | Stnd Conc (mg/L) | | 33.44 | 3.09 | 39.86 | 35.47 | 19.6400 | 55.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M14 ReAn | BlnkCorr Signal | | 0.006 | 0.006 | 0.007 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 38.17 | 38.46 | 40.48 | 39.04 | 1.2583 | 3.22 |
| | Stnd Conc (mg/L) | | 38.17 | 38.46 | 40.48 | 39.04 | 1.2583 | 3.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M15 ReAn | BlnkCorr Signal | | 0.008 | 0.006 | 0.007 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 49.62 | 39.30 | 43.30 | 44.08 | 5.2033 | 11.80 |
| | Stnd Conc (mg/L) | | 49.62 | 39.30 | 43.30 | 44.08 | 5.2033 | 11.80 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 6M16 ReAn | BlnkCorr Signal | | 0.005 | 0.007 | 0.007 | 0.006 | 0.0012 | 19.25 |
| | sample conc (mg/L) | | 33.73 | 40.27 | 41.97 | 38.66 | 4.3505 | 11.25 |
| | Stnd Conc (mg/L) | | 33.73 | 40.27 | 41.97 | 38.66 | 4.3505 | 11.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M1 ReAn | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 47.35 | 49.31 | 48.40 | 48.36 | 0.9808 | 2.03 |
| | Stnd Conc (mg/L) | | 47.35 | 49.31 | 48.40 | 48.36 | 0.9808 | 2.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M2 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 42.59 | 44.86 | 43.45 | 43.63 | 1.1461 | 2.63 |
| | Stnd Conc (mg/L) | | 42.59 | 44.86 | 43.45 | 43.63 | 1.1461 | 2.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M3 ReAn | BlnkCorr Signal | | 0.006 | 0.006 | 0.007 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 39.87 | 37.54 | 44.99 | 40.80 | 3.8111 | 9.34 |
| | Stnd Conc (mg/L) | | 39.87 | 37.54 | 44.99 | 40.80 | 3.8111 | 9.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M4 ReAn | BlnkCorr Signal | | 0.007 | 0.006 | 0.006 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 44.19 | 38.90 | 39.93 | 41.01 | 2.8045 | 6.84 |
| | Stnd Conc (mg/L) | | 44.19 | 38.90 | 39.93 | 41.01 | 2.8045 | 6.84 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn1 | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 35.78 | 39.47 | 35.88 | 37.04 | 2.1021 | 5.68 |
| | Stnd Conc (mg/L) | | 35.78 | 39.47 | 35.88 | 37.04 | 2.1021 | 5.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn1 | BlnkCorr Signal | | 0.007 | 0.005 | 0.006 | 0.006 | 0.0010 | 16.67 |
| | sample conc (mg/L) | | 43.50 | 30.86 | 37.56 | 37.31 | 6.3238 | 16.95 |
| | Stnd Conc (mg/L) | | 43.50 | 30.86 | 37.56 | 37.31 | 6.3238 | 16.95 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn1 | BlnkCorr Signal | | 0.005 | 0.006 | 0.005 | 0.005 | 0.0006 | 11.55 |
| | sample conc (mg/L) | | 32.82 | 34.39 | 32.80 | 33.33 | 0.9123 | 2.74 |
| | Stnd Conc (mg/L) | | 32.82 | 34.39 | 32.80 | 33.33 | 0.9123 | 2.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn1 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 29.02 | 31.86 | 31.71 | 30.86 | 1.5981 | 5.18 |
| | Stnd Conc (mg/L) | | 29.02 | 31.86 | 31.71 | 30.86 | 1.5981 | 5.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn2 | BlnkCorr Signal | | 0.013 | 0.013 | 0.012 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 81.81 | 79.10 | 74.49 | 78.47 | 3.7009 | 4.72 |
| | Stnd Conc (mg/L) | | 81.81 | 79.10 | 74.49 | 78.47 | 3.7009 | 4.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn2 | BlnkCorr Signal | | 0.005 | 0.006 | 0.004 | 0.005 | 0.0010 | 20.00 |
| | sample conc (mg/L) | | 32.06 | 36.39 | 26.32 | 31.59 | 5.0514 | 15.99 |
| | Stnd Conc (mg/L) | | 32.06 | 36.39 | 26.32 | 31.59 | 5.0514 | 15.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn2 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 29.27 | 31.98 | 31.39 | 30.88 | 1.4252 | 4.62 |
| | Stnd Conc (mg/L) | | 29.27 | 31.98 | 31.39 | 30.88 | 1.4252 | 4.62 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn2 | BlnkCorr Signal | | 0.004 | 0.005 | 0.004 | 0.005 | 0.0006 | 11.55 |
| | sample conc (mg/L) | | 27.63 | 28.80 | 27.42 | 27.95 | 0.7436 | 2.66 |
| | Stnd Conc (mg/L) | | 27.63 | 28.80 | 27.42 | 27.95 | 0.7436 | 2.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn3 | BlnkCorr Signal | | 0.021 | 0.022 | 0.022 | 0.022 | 0.0006 | 2.62 |
| | sample conc (mg/L) | | 135.80 | 144.00 | 145.40 | 141.80 | 5.1859 | 3.66 |
| | Stnd Conc (mg/L) | | 135.80 | 144.00 | 145.40 | 141.80 | 5.1859 | 3.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn3 | BlnkCorr Signal | | 0.006 | 0.005 | 0.005 | 0.005 | 0.0006 | 11.55 |
| | sample conc (mg/L) | | 36.10 | 32.35 | 33.24 | 33.90 | 1.9593 | 5.78 |
| | Stnd Conc (mg/L) | | 36.10 | 32.35 | 33.24 | 33.90 | 1.9593 | 5.78 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn3 | BlnkCorr Signal | | 0.005 | 0.006 | 0.005 | 0.005 | 0.0006 | 11.55 |
| | sample conc (mg/L) | | 32.03 | 36.80 | 32.52 | 33.81 | 2.6240 | 7.76 |
| | Stnd Conc (mg/L) | | 32.03 | 36.80 | 32.52 | 33.81 | 2.6240 | 7.76 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn3 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 28.35 | 31.28 | 28.85 | 29.49 | 1.5674 | 5.31 |
| | Stnd Conc (mg/L) | | 28.35 | 31.28 | 28.85 | 29.49 | 1.5674 | 5.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M1 ReAn3 | BlnkCorr Signal | | 0.027 | 0.028 | 0.028 | 0.028 | 0.0006 | 2.06 |
| | sample conc (mg/L) | | 179.90 | 183.30 | 186.20 | 183.10 | 3.1533 | 1.72 |
| | Stnd Conc (mg/L) | | 179.90 | 183.30 | 186.20 | 183.10 | 3.1533 | 1.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M2 ReAn3 | BlnkCorr Signal | | 0.016 | 0.019 | 0.017 | 0.017 | 0.0015 | 8.99 |
| | sample conc (mg/L) | | 104.00 | 121.60 | 110.70 | 112.10 | 8.8831 | 7.92 |
| | Stnd Conc (mg/L) | | 104.00 | 121.60 | 110.70 | 112.10 | 8.8831 | 7.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M3 ReAn3 | BlnkCorr Signal | | 0.009 | 0.010 | 0.011 | 0.010 | 0.0010 | 10.00 |
| | sample conc (mg/L) | | 57.38 | 60.87 | 67.20 | 61.81 | 4.9780 | 8.05 |
| | Stnd Conc (mg/L) | | 57.38 | 60.87 | 67.20 | 61.81 | 4.9780 | 8.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M4 ReAn3 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 46.86 | 48.41 | 50.03 | 48.43 | 1.5851 | 3.27 |
| | Stnd Conc (mg/L) | | 46.86 | 48.41 | 50.03 | 48.43 | 1.5851 | 3.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M5 ReAn3 | BlnkCorr Signal | | 0.010 | 0.011 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 109.40 | 119.80 | 122.00 | 117.10 | 6.7300 | 5.75 |
| | Stnd Conc (mg/L) | | 109.40 | 119.80 | 122.00 | 117.10 | 6.7300 | 5.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M6 ReAn3 | BlnkCorr Signal | | 0.009 | 0.010 | 0.010 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 96.09 | 106.80 | 103.90 | 102.30 | 5.5394 | 5.41 |
| | Stnd Conc (mg/L) | | 96.09 | 106.80 | 103.90 | 102.30 | 5.5394 | 5.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M7 ReAn3 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 96.64 | 94.38 | 101.20 | 97.41 | 3.4740 | 3.57 |
| | Stnd Conc (mg/L) | | 96.64 | 94.38 | 101.20 | 97.41 | 3.4740 | 3.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M8 ReAn3 | BlnkCorr Signal | | 0.009 | 0.009 | 0.010 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 102.00 | 101.80 | 105.50 | 103.10 | 2.0809 | 2.02 |
| | Stnd Conc (mg/L) | | 102.00 | 101.80 | 105.50 | 103.10 | 2.0809 | 2.02 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M9 ReAn3 | BlnkCorr Signal | | 0.009 | 0.010 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 101.40 | 112.70 | 108.00 | 107.40 | 5.6766 | 5.29 |
| | Stnd Conc (mg/L) | | 101.40 | 112.70 | 108.00 | 107.40 | 5.6766 | 5.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M10 ReAn3 | BlnkCorr Signal | | 0.010 | 0.010 | 0.011 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 113.10 | 107.90 | 119.60 | 113.60 | 5.8620 | 5.16 |
| | Stnd Conc (mg/L) | | 113.10 | 107.90 | 119.60 | 113.60 | 5.8620 | 5.16 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M11 ReAn3 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 125.40 | 118.60 | 118.30 | 120.80 | 4.0154 | 3.32 |
| | Stnd Conc (mg/L) | | 125.40 | 118.60 | 118.30 | 120.80 | 4.0154 | 3.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M12 ReAn3 | BlnkCorr Signal | | 0.011 | 0.012 | 0.012 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 117.90 | 127.60 | 127.30 | 124.30 | 5.5157 | 4.44 |
| | Stnd Conc (mg/L) | | 117.90 | 127.60 | 127.30 | 124.30 | 5.5157 | 4.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn4 | BlnkCorr Signal | | 0.010 | 0.011 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 106.20 | 117.00 | 122.30 | 115.20 | 8.2051 | 7.12 |
| | Stnd Conc (mg/L) | | 106.20 | 117.00 | 122.30 | 115.20 | 8.2051 | 7.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn4 | BlnkCorr Signal | | 0.011 | 0.010 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 118.50 | 108.70 | 105.10 | 110.80 | 6.9349 | 6.26 |
| | Stnd Conc (mg/L) | | 118.50 | 108.70 | 105.10 | 110.80 | 6.9349 | 6.26 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn4 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 111.00 | 109.40 | 110.70 | 110.40 | 0.8505 | 0.77 |
| | Stnd Conc (mg/L) | | 111.00 | 109.40 | 110.70 | 110.40 | 0.8505 | 0.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn4 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 117.30 | 118.80 | 115.00 | 117.00 | 1.9140 | 1.64 |
| | Stnd Conc (mg/L) | | 117.30 | 118.80 | 115.00 | 117.00 | 1.9140 | 1.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn5 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 146.80 | 144.00 | 145.70 | 145.50 | 1.4107 | 0.97 |
| | Stnd Conc (mg/L) | | 146.80 | 144.00 | 145.70 | 145.50 | 1.4107 | 0.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn5 | BlnkCorr Signal | | 0.009 | 0.009 | 0.008 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 101.30 | 102.30 | 88.40 | 97.33 | 7.7526 | 7.97 |
| | Stnd Conc (mg/L) | | 101.30 | 102.30 | 88.40 | 97.33 | 7.7526 | 7.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn5 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 87.24 | 82.74 | 85.27 | 85.08 | 2.2558 | 2.65 |
| | Stnd Conc (mg/L) | | 87.24 | 82.74 | 85.27 | 85.08 | 2.2558 | 2.65 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn5 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 72.38 | 70.93 | 77.62 | 73.65 | 3.5194 | 4.78 |
| | Stnd Conc (mg/L) | | 72.38 | 70.93 | 77.62 | 73.65 | 3.5194 | 4.78 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn6 | BlnkCorr Signal | | 0.230 | 0.024 | 0.022 | 0.023 | 0.1195 | 519.63 |
| | sample conc (mg/L) | | 264.90 | 275.10 | 250.70 | 263.60 | 12.2545 | 4.65 |
| | Stnd Conc (mg/L) | | 264.90 | 275.10 | 250.70 | 263.60 | 12.2545 | 4.65 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn6 | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 64.84 | 89.71 | 61.19 | 61.91 | 15.5200 | 25.07 |
| | Stnd Conc (mg/L) | | 94.84 | 89.71 | 61.19 | 61.91 | 18.1293 | 29.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn6 | BlnkCorr Signal | | 0.005 | 0.004 | 0.004 | 0.004 | 0.0006 | 14.43 |
| | sample conc (mg/L) | | 48.09 | 37.31 | 39.55 | 41.65 | 5.6885 | 13.66 |
| | Stnd Conc (mg/L) | | 48.09 | 37.31 | 39.55 | 41.65 | 5.6885 | 13.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn6 | BlnkCorr Signal | | 0.002 | 0.003 | 0.003 | 0.003 | 0.0006 | 19.25 |
| | sample conc (mg/L) | | 25.53 | 36.87 | 33.86 | 32.09 | 5.8743 | 18.31 |
| | Stnd Conc (mg/L) | | 25.53 | 36.87 | 33.86 | 32.09 | 5.8743 | 18.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M1 ReAn6 | BlnkCorr Signal | | 0.031 | 0.032 | 0.032 | 0.320 | 0.0006 | 0.18 |
| | sample conc (mg/L) | | 188.30 | 190.40 | 192.50 | 190.40 | 2.1000 | 1.10 |
| | Stnd Conc (mg/L) | | 188.30 | 190.40 | 192.50 | 190.40 | 2.1000 | 1.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M2 ReAn6 | BlnkCorr Signal | | 0.034 | 0.036 | 0.037 | 0.036 | 0.0015 | 4.24 |
| | sample conc (mg/L) | | 206.60 | 215.60 | 221.90 | 214.70 | 7.6896 | 3.58 |
| | Stnd Conc (mg/L) | | 206.60 | 215.60 | 221.90 | 214.70 | 7.6896 | 3.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M3 ReAn6 | BlnkCorr Signal | | 0.022 | 0.021 | 0.021 | 0.021 | 0.0006 | 2.75 |
| | sample conc (mg/L) | | 132.80 | 122.90 | 123.30 | 126.30 | 5.6039 | 4.44 |
| | Stnd Conc (mg/L) | | 132.80 | 122.90 | 123.30 | 126.30 | 5.6039 | 4.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M4 ReAn6 | BlnkCorr Signal | | 0.017 | 0.017 | 0.017 | 0.017 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 97.96 | 99.40 | 103.00 | 100.10 | 2.5960 | 2.59 |
| | Stnd Conc (mg/L) | | 97.96 | 99.40 | 103.00 | 100.10 | 2.5960 | 2.59 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M5 ReAn6 | BlnkCorr Signal | | 0.015 | 0.015 | 0.015 | 0.015 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 87.34 | 87.64 | 87.48 | 87.49 | 0.1501 | 0.17 |
| | Stnd Conc (mg/L) | | 87.34 | 87.64 | 87.48 | 87.49 | 0.1501 | 0.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M6 ReAn6 | BlnkCorr Signal | | 0.011 | 0.012 | 0.012 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 67.03 | 67.83 | 68.26 | 67.71 | 0.6242 | 0.92 |
| | Stnd Conc (mg/L) | | 67.03 | 67.83 | 68.26 | 67.71 | 0.6242 | 0.92 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M7 ReAn6 | BlnkCorr Signal | | 0.010 | 0.011 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 61.13 | 64.20 | 62.79 | 62.70 | 1.5367 | 2.45 |
| | Stnd Conc (mg/L) | | 61.13 | 64.20 | 62.79 | 62.70 | 1.5367 | 2.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M8 ReAn6 | BlnkCorr Signal | | 0.010 | 0.010 | 0.011 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 60.63 | 60.99 | 61.93 | 61.18 | 0.6712 | 1.10 |
| | Stnd Conc (mg/L) | | 60.63 | 60.99 | 61.93 | 61.18 | 0.6712 | 1.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M9 ReAn6 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 60.85 | 61.03 | 61.45 | 61.11 | 0.3079 | 0.50 |
| | Stnd Conc (mg/L) | | 60.85 | 61.03 | 61.45 | 61.11 | 0.3079 | 0.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M10 ReAn6 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 58.51 | 58.64 | 59.00 | 58.72 | 0.2538 | 0.43 |
| | Stnd Conc (mg/L) | | 58.51 | 58.64 | 59.00 | 58.72 | 0.2538 | 0.43 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M11 ReAn6 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.02 | 55.57 | 54.93 | 55.17 | 0.3465 | 0.63 |
| | Stnd Conc (mg/L) | | 55.02 | 55.57 | 54.93 | 55.17 | 0.3465 | 0.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M12 ReAn6 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 52.22 | 54.32 | 54.63 | 53.72 | 1.3111 | 2.44 |
| | Stnd Conc (mg/L) | | 52.22 | 54.32 | 54.63 | 53.72 | 1.3111 | 2.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M13 ReAn6 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 66.89 | 65.66 | 67.61 | 66.72 | 0.9861 | 1.48 |
| | Stnd Conc (mg/L) | | 66.89 | 65.66 | 67.61 | 66.72 | 0.9861 | 1.48 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M14 ReAn6 | BlnkCorr Signal | | 0.011 | 0.010 | 0.011 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 62.00 | 61.38 | 61.88 | 61.75 | 0.3288 | 0.53 |
| | Stnd Conc (mg/L) | | 62.00 | 61.38 | 61.88 | 61.75 | 0.3288 | 0.53 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 10g/L ReAn7 | BlnkCorr Signal | | 0.020 | 0.019 | 0.019 | 0.019 | 0.0006 | 3.04 |
| | sample conc (mg/L) | | 118.10 | 114.10 | 114.10 | 115.50 | 2.3094 | 2.00 |
| | Stnd Conc (mg/L) | | 118.10 | 114.10 | 114.10 | 115.50 | 2.3094 | 2.00 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn7 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 64.51 | 65.17 | 63.83 | 64.50 | 0.6700 | 1.04 |
| | Stnd Conc (mg/L) | | 64.51 | 65.17 | 63.83 | 64.50 | 0.6700 | 1.04 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn7 | BlnkCorr Signal | | 0.009 | 0.010 | 0.009 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 55.33 | 56.09 | 55.48 | 55.63 | 0.4025 | 0.72 |
| | Stnd Conc (mg/L) | | 55.33 | 56.09 | 55.48 | 55.63 | 0.4025 | 0.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn7 | BlnkCorr Signal | | 0.010 | 0.009 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 56.15 | 55.44 | 56.53 | 56.04 | 0.5533 | 0.99 |
| | Stnd Conc (mg/L) | | 56.15 | 55.44 | 56.53 | 56.04 | 0.5533 | 0.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 3g/L ReAn8 | BlnkCorr Signal | | 0.043 | 0.042 | 0.042 | 0.043 | 0.0006 | 1.34 |
| | sample conc (mg/L) | | 261.60 | 258.70 | 258.80 | 259.70 | 1.6462 | 0.63 |
| | Stnd Conc (mg/L) | | 261.60 | 258.70 | 258.80 | 259.70 | 1.6462 | 0.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 1 ReAn8 | BlnkCorr Signal | | 0.014 | 0.014 | 0.014 | 0.014 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 84.90 | 84.75 | 84.13 | 84.59 | 0.4082 | 0.48 |
| | Stnd Conc (mg/L) | | 84.90 | 84.75 | 84.13 | 84.59 | 0.4082 | 0.48 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 2 ReAn8 | BlnkCorr Signal | | 0.013 | 0.014 | 0.013 | 0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | 78.19 | 80.41 | 78.42 | 79.01 | 1.2208 | 1.55 |
| | Stnd Conc (mg/L) | | 78.19 | 80.41 | 78.42 | 79.01 | 1.2208 | 1.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 Wash 3 ReAn8 | BlnkCorr Signal | | 0.013 | 0.013 | 0.014 | 0.014 | 0.0006 | 4.12 |
| | sample conc (mg/L) | | 79.41 | 79.29 | 80.67 | 79.79 | 0.7645 | 0.96 |
| | Stnd Conc (mg/L) | | 79.41 | 79.29 | 80.67 | 79.79 | 0.7645 | 0.96 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M1 ReAn8 | BlnkCorr Signal | | 0.075 | 0.076 | 0.008 | 0.076 | 0.0391 | 51.51 |
| | sample conc (mg/L) | | 473.30 | 480.30 | 486.50 | 480.00 | 6.6040 | 1.38 |
| | Stnd Conc (mg/L) | | 473.30 | 480.30 | 486.50 | 480.00 | 6.6040 | 1.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M2 ReAn8 | BlnkCorr Signal | | 0.049 | 0.050 | 0.050 | 0.050 | 0.0006 | 1.15 |
| | sample conc (mg/L) | | 303.30 | 306.70 | 306.60 | 305.50 | 1.9348 | 0.63 |
| | Stnd Conc (mg/L) | | 303.30 | 306.70 | 306.60 | 305.50 | 1.9348 | 0.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M3 ReAn8 | BlnkCorr Signal | | 0.029 | 0.029 | 0.029 | 0.029 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 172.70 | 171.70 | 172.70 | 172.40 | 0.5774 | 0.33 |
| | Stnd Conc (mg/L) | | 172.70 | 171.70 | 172.70 | 172.40 | 0.5774 | 0.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T2 8M4 ReAn8 | BlnkCorr Signal | | 0.021 | 0.021 | 0.021 | 0.021 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 126.50 | 125.60 | 127.00 | 126.40 | 0.7095 | 0.56 |
| | Stnd Conc (mg/L) | | 126.50 | 125.60 | 127.00 | 126.40 | 0.7095 | 0.56 |

**XRF raw data - MIP Test 2**

% to mg/L convertion

1% = 1g/100ml = 10g/1000ml = 10,000mg/1000ml = 10000mg/L

| ID | Element | XRF % | concentration (mg/L) |
|---|---|---|---|
| Before Rinse | Ta | 0.382 | 3820 |
| | Nb | 0.289 | 2890 |
| | Ti | 0.287 | 2870 |
| | Mo | 0.044 | 440 |
| | Bal | 97.87 | 978700 |
| | Zr | 0.031 | 310 |
| | Si | 0.005 | 50 |
| | Bi | 0.004 | 40 |
| | As | 0.003 | 30 |
| | **Re** | **1.11** | **11100** |
| | Co | 0.004 | 40 |
| | V | 0.199 | 1990 |
| After Rinse | Ta | 0.118 | 1180 |
| | Nb | 0.316 | 3160 |

| | | | |
|---|---|---|---|
| 1M1 | Sn | 0.006 | 60 |
| | Ti | 0.419 | 4190 |
| | Fe | 0.008 | 80 |
| | Bal | 98.86 | 988600 |
| | Sb | 0.004 | 40 |
| | Mo | 0.051 | 510 |
| | Zr | 0.036 | 360 |
| | Sr | 0.005 | 50 |
| | Rb | 0.002 | 20 |
| | Bi | 0.004 | 40 |
| | **Re** | **0.071** | **710** |
| | V | 0.279 | 2790 |
| | Ta | 0.104 | 1040 |
| | Nb | 0.304 | 3040 |
| | Sn | 0.004 | 40 |
| | Ti | 0.394 | 3940 |
| | Fe | 0.01 | 100 |
| | Bal | 98.88 | 988800 |
| | Sb | 0.003 | 30 |
| | Mo | 0.049 | 490 |
| | Zr | 0.034 | 340 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.064** | **640** |
| | V | 0.307 | 3070 |
| 1M2 | Ta | 0.104 | 1040 |
| | Nb | 0.309 | 3090 |
| | Ti | 0.494 | 4940 |
| | Bal | 98.79 | 987900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.05 | 500 |
| | Zr | 0.034 | 340 |
| | Sr | 0.005 | 50 |
| | Rb | 0.002 | 20 |
| | Bi | 0.004 | 40 |
| | **Re** | **0.054** | **540** |
| | V | 0.319 | 3190 |
| 1M3 | Ta | 0.098 | 980 |
| | Nb | 0.314 | 3140 |
| | Sn | 0.004 | 40 |
| | Ti | 0.529 | 5290 |
| | Fe | 0.015 | 150 |
| | Bal | 98.75 | 987500 |
| | Sb | 0.004 | 40 |

| | | | |
|---|---|---|---|
| 1M4 | Mo | 0.05 | 500 |
| | Zr | 0.036 | 360 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.045** | **450** |
| | V | 0.321 | 3210 |
| | Ta | 0.088 | 880 |
| | Nb | 0.313 | 3130 |
| | Sn | 0.006 | 60 |
| | Ti | 0.458 | 4580 |
| | Fe | 0.007 | 70 |
| | Bal | 98.85 | 988500 |
| | Sb | 0.005 | 50 |
| | Mo | 0.051 | 510 |
| | Zr | 0.036 | 360 |
| | Sr | 0.005 | 50 |
| | Bi | 0.004 | 40 |
| | **Re** | **0.055** | **550** |
| | V | 0.286 | 2860 |
| 1M5 | Ta | 0.114 | 1140 |
| | Nb | 0.316 | 3160 |
| | Ti | 0.559 | 5590 |
| | Fe | 0.034 | 340 |
| | Bal | 98.71 | 987100 |
| | Sb | 0.004 | 40 |
| | Mo | 0.052 | 520 |
| | Zr | 0.036 | 360 |
| | Sr | 0.005 | 50 |
| | Bi | 0.004 | 40 |
| | **Re** | **0.035** | **350** |
| | V | 0.315 | 3150 |
| 3M1 | Ta | 0.107 | 1070 |
| | Nb | 0.308 | 3080 |
| | Sn | 0.005 | 50 |
| | Ti | 0.429 | 4290 |
| | Fe | 0.017 | 170 |
| | Bal | 98.88 | 988800 |
| | Sb | 0.004 | 40 |
| | Mo | 0.05 | 500 |
| | Zr | 0.034 | 340 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.037** | **370** |
| | V | 0.292 | 2920 |

| | | | |
|---|---|---|---|
| 3M2 | Ta | 0.102 | 1020 |
| | Nb | 0.243 | 2430 |
| | Sn | 0.004 | 40 |
| | Ti | 0.327 | 3270 |
| | Bal | 99.05 | 990500 |
| | Sb | 0.003 | 30 |
| | Mo | 0.036 | 360 |
| | Zr | 0.024 | 240 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.065** | **650** |
| | V | 0.275 | 2750 |
| 3M3 | Ta | 0.081 | 810 |
| | Nb | 0.238 | 2380 |
| | Sn | 0.005 | 50 |
| | Ti | 0.312 | 3120 |
| | Bal | 99.09 | 990900 |
| | Mo | 0.034 | 340 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.054** | **540** |
| | V | 0.285 | 2850 |
| 3M4 | Ta | 0.091 | 910 |
| | Nb | 0.234 | 2340 |
| | Sn | 0.003 | 30 |
| | Ti | 0.32 | 3200 |
| | Bal | 99.1 | 991000 |
| | Sb | 0.004 | 40 |
| | Mo | 0.035 | 350 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.061** | **610** |
| | V | 0.253 | 2530 |
| 3M5 | Ta | 0.082 | 820 |
| | Nb | 0.231 | 2310 |
| | Sn | 0.004 | 40 |
| | Ti | 0.261 | 2610 |
| | Bal | 99.16 | 991600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |

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|---|---|---|---|
| | Bi | 0.002 | 20 |
| | **Re** | **0.054** | **540** |
| | V | 0.267 | 2670 |
| 3M6 | Ta | 0.087 | 870 |
| | Nb | 0.249 | 2490 |
| | Ti | 0.297 | 2970 |
| | Bal | 99.1 | 991000 |
| | Sb | 0.003 | 30 |
| | Mo | 0.037 | 370 |
| | Zr | 0.024 | 240 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.051** | **510** |
| | V | 0.274 | 2740 |
| 3M7 | Ta | 0.077 | 770 |
| | Nb | 0.25 | 2500 |
| | Sn | 0.005 | 50 |
| | Ti | 0.291 | 2910 |
| | Bal | 99.13 | 991300 |
| | Sb | 0.004 | 40 |
| | Mo | 0.037 | 370 |
| | Zr | 0.025 | 250 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.049** | **490** |
| | V | 0.261 | 2610 |
| 3M8 | Ta | 0.106 | 1060 |
| | Nb | 0.242 | 2420 |
| | Sn | 0.004 | 40 |
| | Ti | 0.327 | 3270 |
| | Bal | 99.05 | 990500 |
| | Sb | 0.003 | 30 |
| | Mo | 0.037 | 370 |
| | Zr | 0.025 | 250 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.055** | **550** |
| | V | 0.283 | 2830 |
| 6M1 | Ta | 0.085 | 850 |
| | Nb | 0.22 | 2200 |
| | Ti | 0.274 | 2740 |
| | Bal | 99.18 | 991800 |
| | Mo | 0.031 | 310 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |

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|---|---|---|---|
| | Bi | 0.003 | 30 |
| | **Re** | **0.039** | **390** |
| | V | 0.257 | 2570 |
| 6M2 | Ta | 0.083 | 830 |
| | Nb | 0.222 | 2220 |
| | Ti | 0.303 | 3030 |
| | Fe | 0.006 | 60 |
| | Bal | 99.11 | 991100 |
| | Sb | 0.002 | 20 |
| | Mo | 0.032 | 320 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.037** | **370** |
| | V | 0.295 | 2950 |
| 6M3 | Ta | 0.09 | 900 |
| | Nb | 0.229 | 2290 |
| | Sn | 0.004 | 40 |
| | Ti | 0.312 | 3120 |
| | Bal | 99.1 | 991000 |
| | Sb | 0.003 | 30 |
| | Mo | 0.034 | 340 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.031** | **310** |
| | V | 0.287 | 2870 |
| 6M4 | Ta | 0.082 | 820 |
| | Nb | 0.218 | 2180 |
| | Sn | 0.003 | 30 |
| | Ti | 0.306 | 3060 |
| | Bal | 99.16 | 991600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.029 | 290 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.032** | **320** |
| | V | 0.257 | 2570 |
| 6M5 | Ta | 0.097 | 970 |
| | Nb | 0.225 | 2250 |
| | Sn | 0.004 | 40 |
| | Ti | 0.331 | 3310 |
| | Fe | 0.01 | 100 |
| | Bal | 99.11 | 991100 |

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|---|---|---|---|
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.034** | **340** |
| | V | 0.253 | 2530 |
| 6M6 | Ta | 0.082 | 820 |
| | Nb | 0.198 | 1980 |
| | Sn | 0.004 | 40 |
| | Ti | 0.292 | 2920 |
| | Bal | 99.2 | 992000 |
| | Mo | 0.025 | 250 |
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.032** | **320** |
| | V | 0.254 | 2540 |
| 6M7 | Ta | 0.089 | 890 |
| | Nb | 0.223 | 2230 |
| | Sn | 0.004 | 40 |
| | Ti | 0.339 | 3390 |
| | Bal | 99.11 | 991100 |
| | Sb | 0.02 | 200 |
| | Mo | 0.031 | 310 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.023** | **230** |
| | V | 0.277 | 2770 |
| 6M8 | Ta | 0.081 | 810 |
| | Nb | 0.216 | 2160 |
| | Ti | 0.325 | 3250 |
| | Fe | 0.008 | 80 |
| | Bal | 99.13 | 991300 |
| | Sb | 0.002 | 20 |
| | Mo | 0.03 | 300 |
| | Zr | 0.02 | 200 |
| | Re | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.023** | **230** |
| | V | 0.279 | 2790 |
| 8M1 | Ta | 0.086 | 860 |
| | Nb | 0.199 | 1990 |
| | Ti | 0.319 | 3190 |

| | | | |
|---|---|---|---|
| | Bal | 99.17 | 991700 |
| | Mo | 0.026 | 260 |
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.017** | **170** |
| | V | 0.273 | 2730 |
| 8M2 | Ta | 0.067 | 670 |
| | Nb | 0.209 | 2090 |
| | Sn | 0.003 | 30 |
| | Ti | 0.329 | 3290 |
| | Fe | 0.01 | 100 |
| | Bal | 99.18 | 991800 |
| | Sb | 0.003 | 30 |
| | Mo | 0.029 | 290 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.013** | **130** |
| | V | 0.24 | 2400 |
| 8M3 | Ta | 0.062 | 620 |
| | Nb | 0.195 | 1950 |
| | Ti | 0.287 | 2870 |
| | Bal | 99.23 | 992300 |
| | Mo | 0.024 | 240 |
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.009** | **90** |
| | V | 0.255 | 2550 |
| 8M4 | Ta | 0.064 | 640 |
| | Nb | 0.209 | 2090 |
| | Ti | 0.258 | 2580 |
| | Bal | 99.25 | 992500 |
| | Mo | 0.027 | 270 |
| | Zr | 0.017 | 170 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.012** | **120** |
| | V | 0.264 | 2640 |
| 8M5 | Ta | 0.088 | 880 |
| | Nb | 0.212 | 2120 |
| | Sn | 0.004 | 40 |
| | Ti | 0.222 | 2220 |
| | Bal | 99.28 | 992800 |

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|---|---|---|---|
| | Mo | 0.03 | 300 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.012** | **120** |
| | V | 0.233 | 2330 |
| 8M6 | Ta | 0.061 | 610 |
| | Nb | 0.209 | 2090 |
| | Sn | 0.005 | 50 |
| | Ti | 0.279 | 2790 |
| | Fe | 0.007 | 70 |
| | Bal | 99.25 | 992500 |
| | Sb | 0.003 | 30 |
| | Mo | 0.029 | 290 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.006** | **60** |
| | V | 0.239 | 2390 |
| 8M7 | Ta | 0.079 | 790 |
| | Nb | 0.201 | 2010 |
| | Ti | 0.325 | 3250 |
| | Bal | 99.17 | 991700 |
| | Sb | 0.003 | 30 |
| | Mo | 0.024 | 240 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.007** | **70** |
| | V | 0.273 | 2730 |
| 8M8 | Ta | 0.086 | 860 |
| | Nb | 0.213 | 2130 |
| | Ti | 0.258 | 2580 |
| | Bal | 99.24 | 992400 |
| | Sb | 0.002 | 20 |
| | Mo | 0.029 | 290 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.009** | **90** |
| | V | 0.244 | 2440 |
| 3000mg/L $NH_4ReO_4$ addition | Ta | 0.493 | 4930 |
| | Nb | 0.224 | 2240 |
| | Sn | 0.004 | 40 |
| | Ti | 0.165 | 1650 |

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|---|---|---|---|
| | Bal | 97.26 | 972600 |
| | Mo | 0.028 | 280 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.004 | 40 |
| | **Re** | **1.85** | **18500** |
| | Co | 0.005 | 50 |
| | V | 0.17 | 1700 |
| Wash 1 | Ta | 0.501 | 5010 |
| | Nb | 0.239 | 2390 |
| | Sn | 0.005 | 50 |
| | Ti | 0.191 | 1910 |
| | Bal | 97.06 | 970600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.026 | 260 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.004 | 40 |
| | **Re** | **2.01** | **20100** |
| | Co | 0.005 | 50 |
| | V | 0.152 | 1520 |
| Wash 2 | Ta | 0.51 | 5100 |
| | Nb | 0.231 | 2310 |
| | Sn | 0.003 | 30 |
| | Ti | 0.163 | 1630 |
| | Bal | 97.02 | 970200 |
| | Mo | 0.028 | 280 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.004 | 40 |
| | **Re** | **2.09** | **20900** |
| | Co | 0.005 | 50 |
| | V | 0.148 | 1480 |
| Wash 3 | Ta | 0.524 | 5240 |
| | Nb | 0.244 | 2440 |
| | Sn | 0.005 | 50 |
| | Ti | 0.181 | 1810 |
| | Bal | 96.96 | 969600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.033 | 330 |
| | Zr | 0.026 | 260 |
| | Sr | 0.003 | 30 |

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|---|---|---|---|
| | Bi | 0.002 | 20 |
| | As | 0.004 | 40 |
| | **Re** | **2.09** | **20900** |
| | Co | 0.004 | 40 |
| | V | 0.164 | 1640 |
| 6M1 A | Ta | 0.49 | 4900 |
| | Nb | 0.194 | 1940 |
| | Ti | 0.155 | 1550 |
| | Bal | 97.68 | 976800 |
| | Mo | 0.022 | 220 |
| | Zr | 0.018 | 180 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | As | 0.005 | 50 |
| | **Re** | **1.47** | **14700** |
| | Co | 0.006 | 60 |
| | V | 0.163 | 1630 |
| 6M2 A | Ta | 0.356 | 3560 |
| | Nb | 0.206 | 2060 |
| | Ti | 0.219 | 2190 |
| | Bal | 97.99 | 979900 |
| | Mo | 0.026 | 260 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.003 | 30 |
| | **Re** | **1.19** | **11900** |
| | Co | 0.004 | 40 |
| | V | 0.16 | 1600 |
| 6M3 A | Ta | 0.337 | 3370 |
| | Nb | 0.207 | 2070 |
| | Sn | 0.003 | 30 |
| | Ti | 0.188 | 1880 |
| | Bal | 98.24 | 982400 |
| | Mo | 0.028 | 280 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.003 | 30 |
| | **Re** | **0.967** | **9670** |
| | V | 0.174 | 1740 |
| 6M4 A | Ta | 0.297 | 2970 |
| | Nb | 0.207 | 2070 |
| | Sn | 0.005 | 50 |
| | Ti | 0.185 | 1850 |

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|---|---|---|---|
| | Bal | 98.44 | 984400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.03 | 300 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.002 | 20 |
| | **Re** | **0.782** | **7820** |
| | V | 0.194 | 1940 |
| 6M5 A | Ta | 0.255 | 2550 |
| | Nb | 0.225 | 2250 |
| | Sn | 0.004 | 40 |
| | Ti | 0.289 | 2890 |
| | Bal | 98.54 | 985400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.034 | 340 |
| | Zr | 0.024 | 240 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | As | 0.002 | 20 |
| | **Re** | **0.585** | **5850** |
| | V | 0.202 | 2020 |
| 6M6 A | Ta | 0.22 | 2200 |
| | Nb | 0.218 | 2180 |
| | Sn | 0.003 | 30 |
| | Ti | 0.262 | 2620 |
| | Bal | 98.62 | 986200 |
| | Sb | 0.002 | 20 |
| | Mo | 0.031 | 310 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.531** | **5310** |
| | V | 0.233 | 2330 |
| 6M7 A | Ta | 0.19 | 1900 |
| | Nb | 0.217 | 2170 |
| | Ti | 0.265 | 2650 |
| | Bal | 98.76 | 987600 |
| | Mo | 0.03 | 300 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.434** | **4340** |
| | V | 0.225 | 2250 |
| 6M8 A | Ta | 0.174 | 1740 |

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|---|---|---|---|
| | Nb | 0.226 | 2260 |
| | Sn | 0.005 | 50 |
| | Ti | 0.301 | 3010 |
| | Bal | 98.74 | 987400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.033 | 330 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Rb | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.406** | **4060** |
| | V | 0.229 | 2290 |
| 6M9 A | Ta | 0.218 | 2180 |
| | Nb | 0.212 | 2120 |
| | Ti | 0.248 | 2480 |
| | Bal | 98.79 | 987900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.029 | 290 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Rb | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.401** | **4010** |
| | V | 0.214 | 2140 |
| 6M10 A | Ta | 0.171 | 1710 |
| | Nb | 0.227 | 2270 |
| | Sn | 0.004 | 40 |
| | Ti | 0.272 | 2720 |
| | Bal | 98.83 | 988300 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.338** | **3380** |
| | V | 0.237 | 2370 |
| 6M11 A | Ta | 0.152 | 1520 |
| | Nb | 0.226 | 2260 |
| | Sn | 0.004 | 40 |
| | Ti | 0.253 | 2530 |
| | Bal | 98.89 | 988900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.033 | 330 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |

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|---|---|---|---|
| | Bi | 0.002 | 20 |
| | **Re** | **0.311** | **3110** |
| | V | 0.237 | 2370 |
| 6M12 A | Ta | 0.153 | 1530 |
| | Nb | 0.227 | 2270 |
| | Sn | 0.004 | 40 |
| | Ti | 0.254 | 2540 |
| | Bal | 98.91 | 989100 |
| | Mo | 0.032 | 320 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Rb | 0.002 | 20 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.285** | **2850** |
| | V | 0.241 | 2410 |
| 6M13 A | Ta | 0.152 | 1520 |
| | Nb | 0.232 | 2320 |
| | Sn | 0.004 | 40 |
| | Ti | 0.284 | 2840 |
| | Bal | 98.91 | 989100 |
| | Sb | 0.004 | 40 |
| | Mo | 0.035 | 350 |
| | Zr | 0.023 | 230 |
| | Sr | 0.004 | 40 |
| | Rb | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.23** | **2300** |
| | V | 0.264 | 2640 |
| 6M14 A | Ta | 0.126 | 1260 |
| | Nb | 0.22 | 2200 |
| | Ti | 0.302 | 3020 |
| | Bal | 98.94 | 989400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.215** | **2150** |
| | V | 0.258 | 2580 |
| 6M15 A | Ta | 0.115 | 1150 |
| | Nb | 0.23 | 2300 |
| | Sn | 0.004 | 40 |
| | Ti | 0.301 | 3010 |
| | Bal | 89.96 | 899600 |
| | Mo | 0.034 | 340 |

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|---|---|---|---|
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Rb | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.201** | **2010** |
| | V | 0.258 | 2580 |
| 6M16 A | Ta | 0.138 | 1380 |
| | Nb | 0.226 | 2260 |
| | Sn | 0.004 | 40 |
| | Ti | 0.309 | 3090 |
| | Bal | 98.95 | 989500 |
| | Sb | 0.003 | 30 |
| | Mo | 0.034 | 340 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Rb | 0.002 | 20 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.186** | **1860** |
| | V | 0.253 | 2530 |
| 8M1 A | Bal | 99.89 | 998900 |
| | Ta | 0.036 | 360 |
| | **Re** | **0.07** | **700** |
| 8M2 A | Bal | 99.9 | 999000 |
| | Ta | 0.037 | 370 |
| | **Re** | **0.061** | **610** |
| 8M3 A | Bal | 99.92 | 999200 |
| | Ta | 0.03 | 300 |
| | **Re** | **0.047** | **470** |
| 8M4 A | Bal | 99.93 | 999300 |
| | Ta | 0.03 | 300 |
| | **Re** | **0.042** | **420** |
| 3000mg/L $NH_4ReO_4$ addition | Bal | 98.52 | 985200 |
| | As | 0.005 | 50 |
| | Ta | 0.171 | 1710 |
| | **Re** | **1.29** | **12900** |
| | Au | 0.008 | 80 |
| Wash 1 | Bal | 98.82 | 988200 |
| | As | 0.004 | 40 |
| | Ta | 0.129 | 1290 |
| | **Re** | **1.04** | **10400** |
| | Au | 0.005 | 50 |
| Wash 2 | Bal | 98.68 | 986800 |
| | As | 0.004 | 40 |
| | Ta | 0.142 | 1420 |
| | **Re** | **1.17** | **11700** |

| | | | |
|---|---|---|---|
| | Au | 0.004 | 40 |
| Wash 3 | Bal | 98.64 | 986400 |
| | As | 0.004 | 40 |
| | Ta | 0.138 | 1380 |
| | **Re** | **1.21** | **12100** |
| | Au | 0.005 | 50 |
| 3000mg/L $NH_4ReO_4$ addition (6000mg/L total) | Bal | 98.5 | 985000 |
| | As | 0.004 | 40 |
| | Ta | 0.161 | 1610 |
| | **Re** | **1.33** | **13300** |
| | Au | 0.007 | 70 |
| Wash 1 | Bal | 98.37 | 983700 |
| | As | 0.006 | 60 |
| | Ta | 0.168 | 1680 |
| | **Re** | **1.45** | **14500** |
| | Au | 0.006 | 60 |
| Wash 2 | Bal | 98.35 | 983500 |
| | As | 0.005 | 50 |
| | Ta | 0.183 | 1830 |
| | **Re** | **1.45** | **14500** |
| | Au | 0.007 | 70 |
| Wash 3 | Bal | 98.38 | 983800 |
| | As | 0.006 | 60 |
| | Ta | 0.156 | 1560 |
| | **Re** | **1.45** | **14500** |
| | Au | 0.007 | 70 |
| 3000mg/L $NH_4ReO_4$ addition (9000mg/L total) | Bal | 98.25 | 982500 |
| | As | 0.006 | 60 |
| | Ta | 0.205 | 2050 |
| | **Re** | **1.53** | **15300** |
| | Au | 0.01 | 100 |
| Wash 1 | Bal | 98.29 | 982900 |
| | As | 0.005 | 50 |
| | Ta | 0.174 | 1740 |
| | **Re** | **1.52** | **15200** |
| | Au | 0.009 | 90 |
| Wash 2 | Bal | 98.48 | 984800 |
| | As | 0.005 | 50 |
| | Ta | 0.171 | 1710 |
| | **Re** | **1.34** | **13400** |
| | Au | 0.007 | 70 |
| Wash 3 | Bal | 98.62 | 986200 |
| | As | 0.005 | 50 |
| | Ta | 0.151 | 1510 |
| | **Re** | **1.21** | **12100** |

| | | | |
|---|---|---|---|
| | Au | 0.007 | 70 |
| 8M1 A | Bal | 99.08 | 990800 |
| | As | 0.005 | 50 |
| | Ta | 0.135 | 1350 |
| | **Re** | **0.776** | **7760** |
| | Au | 0.006 | 60 |
| 8M2 A | Bal | 99.47 | 994700 |
| | As | 0.002 | 20 |
| | Ta | 0.09 | 900 |
| | **Re** | **0.432** | **4320** |
| | Au | 0.004 | 40 |
| 8M3 A | Bal | 99.56 | 995600 |
| | As | 0.002 | 20 |
| | Ta | 0.078 | 780 |
| | **Re** | **0.36** | **3600** |
| | Au | 0.003 | 30 |
| 8M4 A | Bal | 99.64 | 996400 |
| | Ta | 0.06 | 600 |
| | **Re** | **0.296** | **2960** |
| | Au | 0.002 | 20 |
| 8M5 A | Bal | 99.67 | 996700 |
| | Ta | 0.07 | 700 |
| | **Re** | **0.258** | **2580** |
| | Au | 0.002 | 20 |
| 8M6 A | Bal | 99.78 | 997800 |
| | Ta | 0.047 | 470 |
| | **Re** | **0.171** | **1710** |
| 8M7 A | Bal | 99.8 | 998000 |
| | Ta | 0.042 | 420 |
| | **Re** | **0.155** | **1550** |
| 8M8 A | Bal | 99.83 | 998300 |
| | Ta | 0.047 | 470 |
| | **Re** | **0.125** | **1250** |
| 8M9 A | Bal | 99.84 | 998400 |
| | Ta | 0.039 | 390 |
| | **Re** | **0.124** | **1240** |
| 8M10 A | Bal | 99.86 | 998600 |
| | Ta | 0.039 | 390 |
| | **Re** | **0.104** | **1040** |
| 8M11 A | Bal | 99.88 | 998800 |
| | Ta | 0.03 | 300 |
| | **Re** | **0.084** | **840** |
| 8M12 A | Bal | 99.89 | 998900 |
| | Ta | 0.031 | 310 |
| | **Re** | **0.074** | **740** |

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|---|---|---|---|
| 3000mg/L $NH_4ReO_4$ addition | Bal | 98.85 | 988500 |
| | As | 0.002 | 20 |
| | Ta | 0.119 | 1190 |
| | **Re** | **1.02** | **10200** |
| | Au | 0.006 | 60 |
| Wash 1 | Bal | 98.83 | 988300 |
| | As | 0.003 | 30 |
| | Ta | 0.131 | 1310 |
| | **Re** | **1.03** | **10300** |
| | Au | 0.006 | 60 |
| Wash 2 | Bal | 98.79 | 987900 |
| | As | 0.003 | 30 |
| | Ta | 0.133 | 1330 |
| | **Re** | **1.06** | **10600** |
| | Au | 0.005 | 50 |
| Wash 3 | Bal | 98.87 | 988700 |
| | As | 0.003 | 30 |
| | Ta | 0.117 | 1170 |
| | **Re** | **1** | **10000** |
| | Au | 0.005 | 50 |
| 3000mg/L $NH_4ReO_4$ addition (6000mg/L total) | Bal | 98.69 | 986900 |
| | As | 0.003 | 30 |
| | Ta | 0.143 | 1430 |
| | **Re** | **1.16** | **11600** |
| | Au | 0.005 | 50 |
| Wash 1 | Bal | 98.8 | 988000 |
| | As | 0.005 | 50 |
| | Ta | 0.145 | 1450 |
| | **Re** | **1.34** | **13400** |
| | Au | 0.007 | 70 |
| Wash 2 | Bal | 98.59 | 985900 |
| | As | 0.004 | 40 |
| | Ta | 0.139 | 1390 |
| | **Re** | **1.27** | **12700** |
| | Au | 0.006 | 60 |
| Wash 3 | Bal | 98.63 | 986300 |
| | As | 0.005 | 50 |
| | Ta | 0.135 | 1350 |
| | **Re** | **1.22** | **12200** |
| | Au | 0.005 | 50 |
| 3000mg/L $NH_4ReO_4$ addition (9000mg/L total) | Bal | 98.48 | 984800 |
| | As | 0.005 | 50 |
| | Ta | 0.16 | 1600 |
| | **Re** | **1.35** | **13500** |
| | Au | 0.006 | 60 |

| | | | |
|---|---|---|---|
| Wash 1 | Bal | 98.63 | 986300 |
| | As | 0.004 | 40 |
| | Ta | 0.139 | 1390 |
| | **Re** | **1.22** | **12200** |
| | Au | 0.005 | 50 |
| Wash 2 | Bal | 98.6 | 986000 |
| | As | 0.004 | 40 |
| | Ta | 0.159 | 1590 |
| | **Re** | **1.24** | **12400** |
| | Au | 0.006 | 60 |
| Wash 3 | Bal | 98.46 | 984600 |
| | As | 0.005 | 50 |
| | Ta | 0.158 | 1580 |
| | **Re** | **1.36** | **13600** |
| | Au | 0.008 | 80 |
| 8M1 A | Bal | 99.22 | 992200 |
| | As | 0.004 | 40 |
| | Ta | 0.11 | 1100 |
| | **Re** | **0.66** | **6600** |
| | Au | 0.006 | 60 |
| 8M2 A | Bal | 99.39 | 993900 |
| | As | 0.003 | 30 |
| | Ta | 0.081 | 810 |
| | **Re** | **0.517** | **5170** |
| | Au | 0.004 | 40 |
| 8M3 A | Bal | 99.52 | 995200 |
| | Ta | 0.074 | 740 |
| | **Re** | **0.399** | **3990** |
| | Au | 0.003 | 30 |
| 8M4 A | Bal | 99.58 | 995800 |
| | Ta | 0.064 | 640 |
| | **Re** | **0.354** | **3540** |
| | Au | 0.002 | 20 |
| 8M5 A | Bal | 99.66 | 996600 |
| | Ta | 0.053 | 530 |
| | **Re** | **0.288** | **2880** |
| 8M6 A | Bal | 99.67 | 996700 |
| | Ta | 0.056 | 560 |
| | **Re** | **0.27** | **2700** |
| 8M7 A | Bal | 99.74 | 997400 |
| | Ta | 0.039 | 390 |
| | **Re** | **0.22** | **2200** |
| 8M8 A | Bal | 99.73 | 997300 |
| | Ta | 0.043 | 430 |
| | **Re** | **0.229** | **2290** |

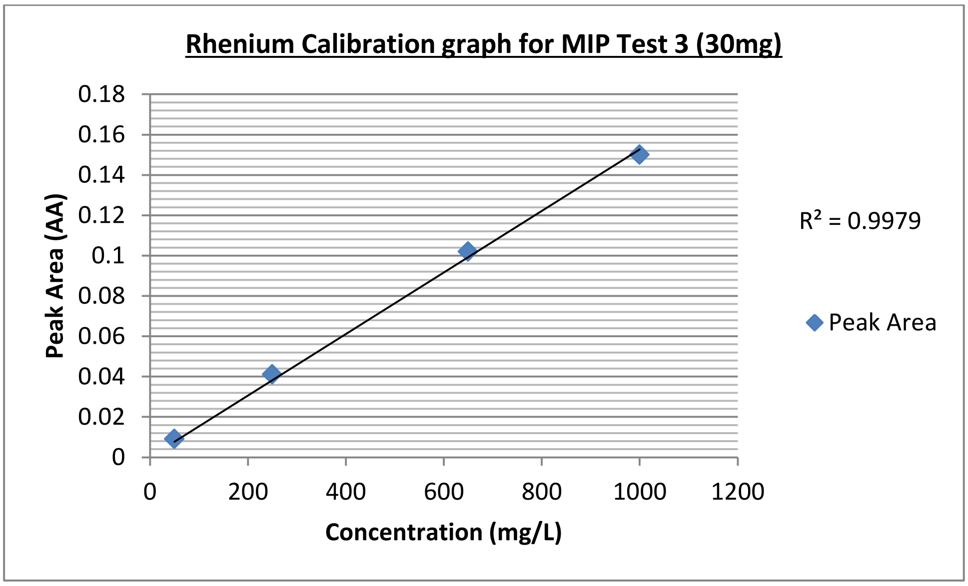
| | | | |
|---|---|---|---|
| 8M9 A | Bal | 99.76 | 997600 |
| | Ta | 0.043 | 430 |
| | **Re** | **0.192** | **1920** |
| 8M10 A | Bal | 99.78 | 997800 |
| | Ta | 0.042 | 420 |
| | **Re** | **0.18** | **1800** |
| 8M11 A | Bal | 99.78 | 997800 |
| | Ta | 0.037 | 370 |
| | **Re** | **0.178** | **1780** |
| 8M12 A | Bal | 99.79 | 997900 |
| | Ta | 0.037 | 370 |
| | **Re** | **0.174** | **1740** |
| 8M13 A | Bal | 99.83 | 998300 |
| | Ta | 0.04 | 400 |
| | **Re** | **0.127** | **1270** |
| 8M14 A | Bal | 99.87 | 998700 |
| | Ta | 0.033 | 330 |
| | **Re** | **0.096** | **960** |
| 10,000mg/L $NH_4ReO_4$ addition | Bal | 98.27 | 982700 |
| | As | 0.006 | 60 |
| | Ta | 0.186 | 1860 |
| | **Re** | **1.53** | **15300** |
| | Au | 0.006 | 60 |
| Wash 1 | Bal | 99.22 | 992200 |
| | As | 0.005 | 50 |
| | Ta | 0.17 | 1700 |
| | **Re** | **1.6** | **16000** |
| | Au | 0.006 | 60 |
| Wash 2 | Bal | 98.33 | 983300 |
| | As | 0.006 | 60 |
| | Ta | 0.172 | 1720 |
| | **Re** | **1.49** | **14900** |
| | Au | 0.005 | 50 |
| Wash 3 | Bal | 98.43 | 984300 |
| | As | 0.006 | 60 |
| | Ta | 0.16 | 1600 |
| | **Re** | **1.4** | **14000** |
| | Au | 0.005 | 50 |
| 3000mg/L $NH_4ReO_4$ addition (13,000mg/L total) | Bal | 98.09 | 980900 |
| | As | 0.006 | 60 |
| | Ta | 0.182 | 1820 |
| | **Re** | **1.72** | **17200** |
| | Au | 0.006 | 60 |
| Wash 1 | Bal | 98.44 | 984400 |
| | As | 0.004 | 40 |

| | | | |
|---|---|---|---|
| | Ta | 0.144 | 1440 |
| | **Re** | **1.41** | **14100** |
| | Au | 0.005 | 50 |
| Wash 2 | Bal | 98.5 | 985000 |
| | As | 0.004 | 40 |
| | Ta | 0.145 | 1450 |
| | **Re** | **1.34** | **13400** |
| | Au | 0.004 | 40 |
| Wash 3 | Bal | 98.4 | 984000 |
| | As | 0.005 | 50 |
| | Ta | 0.156 | 1560 |
| | **Re** | **1.44** | **14400** |
| | Au | 0.005 | 50 |
| 8M1 A | Bal | 99.15 | 991500 |
| | As | 0.004 | 40 |
| | Ta | 0.118 | 1180 |
| | **Re** | **0.719** | **7190** |
| | Au | 0.005 | 50 |
| 8M2 A | Bal | 99.41 | 994100 |
| | As | 0.002 | 20 |
| | Ta | 0.084 | 840 |
| | **Re** | **0.499** | **4990** |
| | Au | 0.002 | 20 |
| 8M3 A | Bal | 99.53 | 995300 |
| | As | 0.002 | 20 |
| | Ta | 0.086 | 860 |
| | **Re** | **0.395** | **3950** |
| | Au | 0.002 | 20 |
| 8M4 A | Bal | 99.55 | 995500 |
| | As | 0.002 | 20 |
| | Ta | 0.064 | 640 |
| | **Re** | **0.377** | **3770** |
| | Au | 0.002 | 20 |

## 7.14. Appendix 14 - MIP Test 3 Calibration graph; XRF and AAS raw data

range: 50 - 1000ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| blank | 0.486 | 0.486 | 0.00000 | 0.00 |
| | 0.486 | | | |
| | 0.486 | | | |
| 50 | 0.008 | 0.009 | 0.00058 | 6.42 |
| | 0.008 | | | |
| | 0.009 | | | |
| 250 | 0.041 | 0.041 | 0.00000 | 0.00 |
| | 0.041 | | | |
| | 0.041 | | | |
| 650 | 0.101 | 0.102 | 0.00058 | 0.57 |
| | 0.102 | | | |
| | 0.102 | | | |
| 1000 | 0.157 | 0.150 | 0.01012 | 6.74 |
| | 0.156 | | | |
| | 0.139 | | | |




## AAS raw data - MIP Test 3

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 A.R Template | BlnkCorr Signal | | -0.012 | -0.012 | -0.013 | -0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | -55.40 | -56.39 | -61.40 | -57.73 | 3.2166 | 5.57 |
| | Stnd Conc (mg/L) | | -55.40 | -56.39 | -61.40 | -57.73 | 3.2166 | 5.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 1M1 Template | BlnkCorr Signal | | -0.018 | -0.018 | -0.017 | -0.018 | 0.0006 | 3.21 |
| | sample conc (mg/L) | | -80.55 | -82.13 | -78.15 | -80.28 | 2.0040 | 2.50 |
| | Stnd Conc (mg/L) | | -80.55 | -82.13 | -78.15 | -80.28 | 2.0040 | 2.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 1M2 Template | BlnkCorr Signal | | -0.020 | -0.020 | -0.020 | -0.020 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | -88.49 | -88.53 | -88.89 | -88.64 | 0.2203 | 0.25 |
| | Stnd Conc (mg/L) | | -88.49 | -88.53 | -88.89 | -88.64 | 0.2203 | 0.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 1M3 Template | BlnkCorr Signal | | -0.021 | -0.022 | -0.023 | -0.022 | 0.0010 | 4.55 |
| | sample conc (mg/L) | | -92.54 | -97.08 | -100.80 | -96.80 | 4.1368 | 4.27 |
| | Stnd Conc (mg/L) | | -92.54 | -97.08 | -100.80 | -96.80 | 4.1368 | 4.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 1M4 Template | BlnkCorr Signal | | -0.023 | -0.022 | -0.023 | -0.023 | 0.0006 | 2.51 |
| | sample conc (mg/L) | | -100.80 | -97.36 | -99.16 | -99.10 | 1.7206 | 1.74 |
| | Stnd Conc (mg/L) | | -100.80 | -97.36 | -99.16 | -99.10 | 1.7206 | 1.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 1M5 Template | BlnkCorr Signal | | -0.029 | -0.030 | -0.028 | -0.029 | 0.0010 | 3.45 |
| | sample conc (mg/L) | | -124.60 | -126.20 | -118.40 | -123.00 | 4.1199 | 3.35 |
| | Stnd Conc (mg/L) | | -124.60 | -126.20 | -118.40 | -123.00 | 4.1199 | 3.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M1 Template | BlnkCorr Signal | | -0.025 | -0.025 | -0.026 | -0.025 | 0.0006 | 2.31 |
| | sample conc (mg/L) | | -107.60 | -109.00 | -113.80 | -110.10 | 3.2517 | 2.95 |
| | Stnd Conc (mg/L) | | -107.60 | -109.00 | -113.80 | -110.10 | 3.2517 | 2.95 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M2 Template | BlnkCorr Signal | | 0.008 | 0.007 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 40.12 | 35.69 | 41.28 | 39.02 | 2.9501 | 7.56 |
| | Stnd Conc (mg/L) | | 40.12 | 35.69 | 41.28 | 39.02 | 2.9501 | 7.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M3 Template | BlnkCorr Signal | | -0.002 | -0.002 | -0.002 | -0.002 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | -10.72 | -11.84 | -9.53 | -10.70 | 1.1532 | 10.78 |
| | Stnd Conc (mg/L) | | -10.72 | -11.84 | -9.53 | -10.70 | 1.1532 | 10.78 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M4 Template | BlnkCorr Signal | | 0.010 | 0.011 | 0.012 | 0.011 | 0.0010 | 9.09 |
| | sample conc (mg/L) | | 47.41 | 48.02 | 52.87 | 49.44 | 2.9918 | 6.05 |
| | Stnd Conc (mg/L) | | 47.41 | 48.02 | 52.87 | 49.44 | 2.9918 | 6.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M5 Template | BlnkCorr Signal | | 0.017 | 0.018 | 0.017 | 0.017 | 0.0006 | 3.40 |
| | sample conc (mg/L) | | 79.96 | 86.26 | 80.28 | 82.17 | 3.5485 | 4.32 |
| | Stnd Conc (mg/L) | | 79.96 | 86.26 | 80.28 | 82.17 | 3.5485 | 4.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M6 Template | BlnkCorr Signal | | 0.018 | 0.020 | 0.020 | 0.019 | 0.0012 | 6.08 |
| | sample conc (mg/L) | | 87.27 | 95.40 | 98.60 | 93.76 | 5.8410 | 6.23 |
| | Stnd Conc (mg/L) | | 87.27 | 95.40 | 98.60 | 93.76 | 5.8410 | 6.23 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M7 Template | BlnkCorr Signal | | 0.022 | 0.022 | 0.021 | 0.022 | 0.0006 | 2.62 |
| | sample conc (mg/L) | | 104.90 | 108.80 | 102.40 | 105.40 | 3.2254 | 3.06 |
| | Stnd Conc (mg/L) | | 104.90 | 108.80 | 102.40 | 105.40 | 3.2254 | 3.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3M8 Template | BlnkCorr Signal | | 0.022 | 0.022 | 0.023 | 0.022 | 0.0006 | 2.62 |
| | sample conc (mg/L) | | 109.10 | 107.10 | 111.20 | 109.10 | 2.0502 | 1.88 |
| | Stnd Conc (mg/L) | | 109.10 | 107.10 | 111.20 | 109.10 | 2.0502 | 1.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M1 Template | BlnkCorr Signal | | 0.021 | 0.021 | 0.022 | 0.021 | 0.0006 | 2.75 |
| | sample conc (mg/L) | | 99.41 | 100.10 | 106.60 | 102.10 | 3.9670 | 3.89 |
| | Stnd Conc (mg/L) | | 99.41 | 100.10 | 106.60 | 102.10 | 3.9670 | 3.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M2 Template | BlnkCorr Signal | | 0.019 | 0.019 | 0.019 | 0.019 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 93.61 | 91.45 | 91.03 | 92.03 | 1.3843 | 1.50 |
| | Stnd Conc (mg/L) | | 93.61 | 91.45 | 91.03 | 92.03 | 1.3843 | 1.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M3 Template | BlnkCorr Signal | | 0.018 | 0.018 | 0.019 | 0.018 | 0.0006 | 3.21 |
| | sample conc (mg/L) | | 87.64 | 86.05 | 88.78 | 87.49 | 1.3712 | 1.57 |
| | Stnd Conc (mg/L) | | 87.64 | 86.05 | 88.78 | 87.49 | 1.3712 | 1.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M4 Template | BlnkCorr Signal | | 0.017 | 0.017 | 0.018 | 0.017 | 0.0006 | 3.40 |
| | sample conc (mg/L) | | 99.01 | 101.90 | 106.30 | 102.40 | 3.6710 | 3.58 |
| | Stnd Conc (mg/L) | | 99.01 | 101.90 | 106.30 | 102.40 | 3.6710 | 3.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M5 Template | BlnkCorr Signal | | 0.022 | 0.023 | 0.023 | 0.022 | 0.0006 | 2.62 |
| | sample conc (mg/L) | | 130.80 | 135.60 | 137.00 | 134.50 | 3.2517 | 2.42 |
| | Stnd Conc (mg/L) | | 130.80 | 135.60 | 137.00 | 134.50 | 3.2517 | 2.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M6 Template | BlnkCorr Signal | | 0.026 | 0.026 | 0.026 | 0.026 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 156.40 | 157.90 | 157.60 | 157.30 | 0.7937 | 0.50 |
| | Stnd Conc (mg/L) | | 156.40 | 157.90 | 157.60 | 157.30 | 0.7937 | 0.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M7 Template | BlnkCorr Signal | | 0.028 | 0.027 | 0.027 | 0.027 | 0.0006 | 2.14 |
| | sample conc (mg/L) | | 169.80 | 164.80 | 163.40 | 166.00 | 3.3645 | 2.03 |
| | Stnd Conc (mg/L) | | 169.80 | 164.80 | 163.40 | 166.00 | 3.3645 | 2.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M8 Template | BlnkCorr Signal | | 0.029 | 0.029 | 0.028 | 0.029 | 0.0006 | 1.99 |
| | sample conc (mg/L) | | 174.90 | 175.80 | 174.00 | 174.90 | 0.9000 | 0.51 |
| | Stnd Conc (mg/L) | | 174.90 | 175.80 | 174.00 | 174.90 | 0.9000 | 0.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M1 Template | BlnkCorr Signal | | 0.028 | 0.027 | 0.028 | 0.028 | 0.0006 | 2.06 |
| | sample conc (mg/L) | | 170.60 | 167.60 | 170.50 | 169.50 | 1.7039 | 1.01 |
| | Stnd Conc (mg/L) | | 170.60 | 167.60 | 170.50 | 169.50 | 1.7039 | 1.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M2 Template | BlnkCorr Signal | | 0.028 | 0.029 | 0.028 | 0.028 | 0.0006 | 2.06 |
| | sample conc (mg/L) | | 169.60 | 174.80 | 168.50 | 171.00 | 3.3650 | 1.97 |
| | Stnd Conc (mg/L) | | 169.60 | 174.80 | 168.50 | 171.00 | 3.3650 | 1.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M3 Template | BlnkCorr Signal | | 0.027 | 0.027 | 0.027 | 0.027 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 166.00 | 165.80 | 165.30 | 165.70 | 0.3606 | 0.22 |
| | Stnd Conc (mg/L) | | 166.00 | 165.80 | 165.30 | 165.70 | 0.3606 | 0.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M4 Template | BlnkCorr Signal | | 0.025 | 0.025 | 0.024 | 0.025 | 0.0006 | 2.31 |
| | sample conc (mg/L) | | 152.50 | 149.40 | 147.90 | 149.90 | 2.3459 | 1.56 |
| | Stnd Conc (mg/L) | | 152.50 | 149.40 | 147.90 | 149.90 | 2.3459 | 1.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M5 Template | BlnkCorr Signal | | 0.012 | 0.011 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 61.24 | 65.32 | 63.78 | 63.45 | 2.0603 | 3.25 |
| | Stnd Conc (mg/L) | | 61.24 | 65.32 | 63.78 | 63.45 | 2.0603 | 3.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M6 Template | BlnkCorr Signal | | 0.013 | 0.012 | 0.012 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 79.99 | 79.01 | 79.84 | 79.61 | 0.5279 | 0.66 |
| | Stnd Conc (mg/L) | | 79.99 | 79.01 | 79.84 | 79.61 | 0.5279 | 0.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M7 Template | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 86.45 | 90.54 | 88.24 | 88.41 | 2.0503 | 2.32 |
| | Stnd Conc (mg/L) | | 86.45 | 90.54 | 88.24 | 88.41 | 2.0503 | 2.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M8 Template | BlnkCorr Signal | | 0.014 | 0.014 | 0.014 | 0.014 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 96.81 | 98.71 | 95.82 | 97.11 | 1.4687 | 1.51 |
| | Stnd Conc (mg/L) | | 96.81 | 98.71 | 95.82 | 97.11 | 1.4687 | 1.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn | BlnkCorr Signal | | 0.014 | 0.014 | 0.013 | 0.014 | 0.0006 | 4.12 |
| | sample conc (mg/L) | | 97.53 | 100.40 | 92.96 | 96.96 | 3.7522 | 3.87 |
| | Stnd Conc (mg/L) | | 97.53 | 100.40 | 92.96 | 96.96 | 3.7522 | 3.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 91.21 | 88.87 | 90.88 | 90.32 | 1.2665 | 1.40 |
| | Stnd Conc (mg/L) | | 91.21 | 88.87 | 90.88 | 90.32 | 1.2665 | 1.40 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn | BlnkCorr Signal | | 0.012 | 0.012 | 0.013 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 86.28 | 85.48 | 88.26 | 86.68 | 1.4311 | 1.65 |
| | Stnd Conc (mg/L) | | 86.28 | 85.48 | 88.26 | 86.68 | 1.4311 | 1.65 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn | BlnkCorr Signal | | 0.011 | 0.010 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 76.66 | 71.31 | 70.66 | 72.88 | 3.2925 | 4.52 |
| | Stnd Conc (mg/L) | | 76.66 | 71.31 | 70.66 | 72.88 | 3.2925 | 4.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M1 ReAn | BlnkCorr Signal | | 0.005 | 0.007 | 0.006 | 0.006 | 0.0010 | 16.67 |
| | sample conc (mg/L) | | 32.80 | 44.64 | 37.46 | 38.30 | 5.9645 | 15.57 |
| | Stnd Conc (mg/L) | | 32.80 | 44.64 | 37.46 | 38.30 | 5.9645 | 15.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M2 ReAn | BlnkCorr Signal | | 0.008 | 0.008 | 0.007 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 48.49 | 47.16 | 45.30 | 46.98 | 1.6023 | 3.41 |
| | Stnd Conc (mg/L) | | 48.49 | 47.16 | 45.30 | 46.98 | 1.6023 | 3.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M3 ReAn | BlnkCorr Signal | | 0.008 | 0.008 | 0.006 | 0.007 | 0.0012 | 16.50 |
| | sample conc (mg/L) | | 49.34 | 48.80 | 40.09 | 46.07 | 5.1916 | 11.27 |
| | Stnd Conc (mg/L) | | 49.34 | 48.80 | 40.09 | 46.07 | 5.1916 | 11.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M4 ReAn | BlnkCorr Signal | | 0.008 | 0.007 | 0.008 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 46.76 | 42.42 | 50.24 | 46.47 | 3.9179 | 8.43 |
| | Stnd Conc (mg/L) | | 46.76 | 42.42 | 50.24 | 46.47 | 3.9179 | 8.43 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M5 ReAn | BlnkCorr Signal | | 0.007 | 0.008 | 0.009 | 0.008 | 0.0010 | 12.50 |
| | sample conc (mg/L) | | 44.39 | 47.43 | 53.39 | 48.40 | 4.5783 | 9.46 |
| | Stnd Conc (mg/L) | | 44.39 | 47.43 | 53.39 | 48.40 | 4.5783 | 9.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M6 ReAn | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 47.80 | 50.03 | 48.81 | 48.88 | 1.1166 | 2.28 |
| | Stnd Conc (mg/L) | | 47.80 | 50.03 | 48.81 | 48.88 | 1.1166 | 2.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M7 ReAn | BlnkCorr Signal | | 0.008 | 0.009 | 0.007 | 0.008 | 0.0010 | 12.50 |
| | sample conc (mg/L) | | 48.60 | 55.64 | 45.96 | 50.07 | 5.0039 | 9.99 |
| | Stnd Conc (mg/L) | | 48.60 | 55.64 | 45.96 | 50.07 | 5.0039 | 9.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M8 ReAn | BlnkCorr Signal | | 0.007 | 0.008 | 0.009 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 45.43 | 49.23 | 53.69 | 49.45 | 4.1344 | 8.36 |
| | Stnd Conc (mg/L) | | 45.43 | 49.23 | 53.69 | 49.45 | 4.1344 | 8.36 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M9 ReAn | BlnkCorr Signal | | 0.008 | 0.009 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 49.89 | 57.80 | 51.13 | 52.94 | 4.2543 | 8.04 |
| | Stnd Conc (mg/L) | | 49.89 | 57.80 | 51.13 | 52.94 | 4.2543 | 8.04 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M10 ReAn | BlnkCorr Signal | | 0.008 | 0.008 | 0.007 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 48.76 | 47.78 | 44.69 | 47.08 | 2.1242 | 4.51 |
| | Stnd Conc (mg/L) | | 48.76 | 47.78 | 44.69 | 47.08 | 2.1242 | 4.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M11 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 42.53 | 42.62 | 46.08 | 43.74 | 2.0241 | 4.63 |
| | Stnd Conc (mg/L) | | 42.53 | 42.62 | 46.08 | 43.74 | 2.0241 | 4.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M12 ReAn | BlnkCorr Signal | | 0.007 | 0.006 | 0.007 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 43.80 | 37.14 | 41.73 | 40.89 | 3.4085 | 8.34 |
| | Stnd Conc (mg/L) | | 43.80 | 37.14 | 41.73 | 40.89 | 3.4085 | 8.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M13 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 43.95 | 40.68 | 44.23 | 42.95 | 1.9737 | 4.60 |
| | Stnd Conc (mg/L) | | 43.95 | 40.68 | 44.23 | 42.95 | 1.9737 | 4.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M14 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.006 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 43.81 | 44.11 | 39.08 | 42.33 | 2.8215 | 6.67 |
| | Stnd Conc (mg/L) | | 43.81 | 44.11 | 39.08 | 42.33 | 2.8215 | 6.67 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M15 ReAn | BlnkCorr Signal | | 0.006 | 0.007 | 0.007 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 39.36 | 44.16 | 45.99 | 43.17 | 3.4241 | 7.93 |
| | Stnd Conc (mg/L) | | 39.36 | 44.16 | 45.99 | 43.17 | 3.4241 | 7.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 6M16 ReAn | BlnkCorr Signal | | 0.007 | 0.006 | 0.008 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 45.06 | 38.66 | 47.05 | 43.59 | 4.3839 | 10.06 |
| | Stnd Conc (mg/L) | | 45.06 | 38.66 | 47.05 | 43.59 | 4.3839 | 10.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M1 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.008 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 43.25 | 45.21 | 48.45 | 45.64 | 2.6261 | 5.75 |
| | Stnd Conc (mg/L) | | 43.25 | 45.21 | 48.45 | 45.64 | 2.6261 | 5.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M2 ReAn | BlnkCorr Signal | | 0.007 | 0.006 | 0.008 | 0.007 | 0.0010 | 14.29 |
| | sample conc (mg/L) | | 41.87 | 39.75 | 46.86 | 42.82 | 3.6503 | 8.52 |
| | Stnd Conc (mg/L) | | 41.87 | 39.75 | 46.86 | 42.82 | 3.6503 | 8.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M3 ReAn | BlnkCorr Signal | | 0.006 | 0.007 | 0.006 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 39.08 | 42.61 | 39.05 | 40.25 | 2.0468 | 5.09 |
| | Stnd Conc (mg/L) | | 39.08 | 42.61 | 39.05 | 40.25 | 2.0468 | 5.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M4 ReAn | BlnkCorr Signal | | 0.006 | 0.008 | 0.008 | 0.007 | 0.0012 | 16.50 |
| | sample conc (mg/L) | | 39.58 | 46.75 | 47.29 | 44.54 | 4.3040 | 9.66 |
| | Stnd Conc (mg/L) | | 39.58 | 46.75 | 47.29 | 44.54 | 4.3040 | 9.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn1 | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 38.69 | 39.63 | 38.71 | 39.01 | 0.5370 | 1.38 |
| | Stnd Conc (mg/L) | | 38.69 | 39.63 | 38.71 | 39.01 | 0.5370 | 1.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn1 | BlnkCorr Signal | | 0.006 | 0.005 | 0.006 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 34.06 | 33.91 | 37.05 | 35.01 | 1.7712 | 5.06 |
| | Stnd Conc (mg/L) | | 34.06 | 33.91 | 37.05 | 35.01 | 1.7712 | 5.06 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn1 | BlnkCorr Signal | | 0.005 | 0.006 | 0.005 | 0.005 | 0.0006 | 11.55 |
| | sample conc (mg/L) | | 29.37 | 39.76 | 28.03 | 32.39 | 6.4205 | 19.82 |
| | Stnd Conc (mg/L) | | 29.37 | 39.76 | 28.03 | 32.39 | 6.4205 | 19.82 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn1 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 30.96 | 33.16 | 33.18 | 32.43 | 1.2760 | 3.93 |
| | Stnd Conc (mg/L) | | 30.96 | 33.16 | 33.18 | 32.43 | 1.2760 | 3.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn2 | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 37.62 | 34.99 | 39.29 | 37.30 | 2.1678 | 5.81 |
| | Stnd Conc (mg/L) | | 37.62 | 34.99 | 39.29 | 37.30 | 2.1678 | 5.81 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn2 | BlnkCorr Signal | | 0.004 | 0.005 | 0.004 | 0.004 | 0.0006 | 14.43 |
| | sample conc (mg/L) | | 26.67 | 28.55 | 24.10 | 26.44 | 2.2339 | 8.45 |
| | Stnd Conc (mg/L) | | 26.67 | 28.55 | 24.10 | 26.44 | 2.2339 | 8.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn2 | BlnkCorr Signal | | 0.004 | 0.004 | 0.005 | 0.004 | 0.0006 | 14.43 |
| | sample conc (mg/L) | | 25.17 | 26.08 | 28.39 | 26.54 | 1.6604 | 6.26 |
| | Stnd Conc (mg/L) | | 25.17 | 26.08 | 28.39 | 26.54 | 1.6599 | 6.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn2 | BlnkCorr Signal | | 0.003 | 0.004 | 0.004 | 0.004 | 0.0006 | 14.43 |
| | sample conc (mg/L) | | 21.07 | 25.98 | 26.53 | 24.53 | 3.0062 | 12.26 |
| | Stnd Conc (mg/L) | | 21.07 | 25.98 | 26.53 | 24.53 | 3.0062 | 12.26 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn3 | BlnkCorr Signal | | 0.015 | 0.017 | 0.016 | 0.016 | 0.0010 | 6.25 |
| | sample conc (mg/L) | | 94.37 | 108.30 | 104.40 | 102.30 | 7.1863 | 7.02 |
| | Stnd Conc (mg/L) | | 94.37 | 108.30 | 104.40 | 102.30 | 7.1863 | 7.02 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn3 | BlnkCorr Signal | | 0.004 | 0.004 | 0.005 | 0.004 | 0.0006 | 14.43 |
| | sample conc (mg/L) | | 21.75 | 23.41 | 28.64 | 24.60 | 3.5958 | 14.62 |
| | Stnd Conc (mg/L) | | 21.75 | 23.41 | 28.64 | 24.60 | 3.5958 | 14.62 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn3 | BlnkCorr Signal | | 0.004 | 0.004 | 0.004 | 0.004 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 24.11 | 24.08 | 25.66 | 24.62 | 0.9037 | 3.67 |
| | Stnd Conc (mg/L) | | 24.11 | 24.08 | 25.66 | 24.62 | 0.9037 | 3.67 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn3 | BlnkCorr Signal | | 0.005 | 0.003 | 0.004 | 0.004 | 0.0010 | 25.00 |
| | sample conc (mg/L) | | 28.45 | 19.02 | 26.38 | 24.62 | 4.9561 | 20.13 |
| | Stnd Conc (mg/L) | | 28.45 | 19.02 | 26.38 | 24.62 | 4.9561 | 20.13 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M1 ReAn3 | BlnkCorr Signal | | 0.022 | 0.023 | 0.024 | 0.023 | 0.0010 | 4.35 |
| | sample conc (mg/L) | | 140.30 | 146.50 | 153.70 | 146.80 | 6.7062 | 4.57 |
| | Stnd Conc (mg/L) | | 140.30 | 146.50 | 153.70 | 146.80 | 6.7062 | 4.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M2 ReAn3 | BlnkCorr Signal | | 0.018 | 0.019 | 0.019 | 0.018 | 0.0006 | 3.21 |
| | sample conc (mg/L) | | 112.80 | 122.20 | 121.00 | 118.70 | 5.1160 | 4.31 |
| | Stnd Conc (mg/L) | | 112.80 | 122.20 | 121.00 | 118.70 | 5.1160 | 4.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M3 ReAn3 | BlnkCorr Signal | | 0.010 | 0.011 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 65.24 | 66.18 | 70.91 | 67.44 | 3.0388 | 4.51 |
| | Stnd Conc (mg/L) | | 65.24 | 66.18 | 70.91 | 67.44 | 3.0388 | 4.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M4 ReAn3 | BlnkCorr Signal | | 0.008 | 0.004 | 0.003 | 0.005 | 0.0026 | 52.92 |
| | sample conc (mg/L) | | 47.44 | 22.83 | 18.37 | 29.55 | 15.6557 | 52.98 |
| | Stnd Conc (mg/L) | | 47.44 | 22.83 | 18.37 | 29.55 | 15.6557 | 52.98 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M5 ReAn3 | BlnkCorr Signal | | 0.010 | 0.010 | 0.012 | 0.011 | 0.0012 | 10.50 |
| | sample conc (mg/L) | | 110.70 | 111.50 | 130.00 | 117.40 | 10.9192 | 9.30 |
| | Stnd Conc (mg/L) | | 110.70 | 111.50 | 130.00 | 117.40 | 10.9192 | 9.30 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M6 ReAn3 | BlnkCorr Signal | | 0.011 | 0.010 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 119.80 | 111.70 | 117.00 | 116.20 | 4.1138 | 3.54 |
| | Stnd Conc (mg/L) | | 119.80 | 111.70 | 117.00 | 116.20 | 4.1138 | 3.54 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M7 ReAn3 | BlnkCorr Signal | | 0.010 | 0.009 | 0.011 | 0.010 | 0.0010 | 10.00 |
| | sample conc (mg/L) | | 108.30 | 102.10 | 119.30 | 109.90 | 8.7109 | 7.93 |
| | Stnd Conc (mg/L) | | 108.30 | 102.10 | 119.30 | 109.90 | 8.7109 | 7.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M8 ReAn3 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 109.30 | 112.80 | 105.40 | 109.10 | 3.7018 | 3.39 |
| | Stnd Conc (mg/L) | | 109.30 | 112.80 | 105.40 | 109.10 | 3.7018 | 3.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M9 ReAn3 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 122.70 | 120.20 | 117.30 | 120.10 | 2.7025 | 2.25 |
| | Stnd Conc (mg/L) | | 122.70 | 120.20 | 117.30 | 120.10 | 2.7025 | 2.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M10 ReAn3 | BlnkCorr Signal | | 0.012 | 0.011 | 0.010 | 0.011 | 0.0010 | 9.09 |
| | sample conc (mg/L) | | 132.20 | 116.70 | 112.90 | 120.60 | 10.2240 | 8.48 |
| | Stnd Conc (mg/L) | | 132.20 | 116.70 | 112.90 | 120.60 | 10.2240 | 8.48 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M11 ReAn3 | BlnkCorr Signal | | 0.011 | 0.011 | 0.012 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 117.30 | 126.00 | 131.30 | 124.90 | 7.0685 | 5.66 |
| | Stnd Conc (mg/L) | | 117.30 | 126.00 | 131.30 | 124.90 | 7.0685 | 5.66 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M12 ReAn3 | BlnkCorr Signal | | 0.012 | 0.011 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 130.70 | 118.10 | 122.50 | 123.80 | 6.3948 | 5.17 |
| | Stnd Conc (mg/L) | | 130.70 | 118.10 | 122.50 | 123.80 | 6.3948 | 5.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn4 | BlnkCorr Signal | | 0.011 | 0.010 | 0.012 | 0.011 | 0.0010 | 9.09 |
| | sample conc (mg/L) | | 121.50 | 111.70 | 126.90 | 120.00 | 7.7054 | 6.42 |
| | Stnd Conc (mg/L) | | 121.50 | 111.70 | 126.90 | 120.00 | 7.7054 | 6.42 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn4 | BlnkCorr Signal | | 0.012 | 0.011 | 0.010 | 0.011 | 0.0010 | 9.09 |
| | sample conc (mg/L) | | 131.70 | 118.70 | 108.60 | 119.60 | 11.5803 | 9.68 |
| | Stnd Conc (mg/L) | | 131.70 | 118.70 | 108.60 | 119.60 | 11.5803 | 9.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn4 | BlnkCorr Signal | | 0.009 | 0.010 | 0.011 | 0.010 | 0.0010 | 10.00 |
| | sample conc (mg/L) | | 100.40 | 105.50 | 115.70 | 107.20 | 7.7904 | 7.27 |
| | Stnd Conc (mg/L) | | 100.40 | 105.50 | 115.70 | 107.20 | 7.7904 | 7.27 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn4 | BlnkCorr Signal | | 0.009 | 0.009 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 102.70 | 99.93 | 107.70 | 103.40 | 3.9380 | 3.81 |
| | Stnd Conc (mg/L) | | 102.70 | 99.93 | 107.70 | 103.40 | 3.9380 | 3.81 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn5 | BlnkCorr Signal | | 0.009 | 0.010 | 0.009 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 100.90 | 106.30 | 101.00 | 102.70 | 3.0892 | 3.01 |
| | Stnd Conc (mg/L) | | 100.90 | 106.30 | 101.00 | 102.70 | 3.0892 | 3.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn5 | BlnkCorr Signal | | 0.008 | 0.007 | 0.007 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 90.02 | 79.45 | 80.88 | 83.45 | 5.7345 | 6.87 |
| | Stnd Conc (mg/L) | | 90.02 | 79.45 | 80.88 | 83.45 | 5.7345 | 6.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn5 | BlnkCorr Signal | | 0.007 | 0.007 | 0.008 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 72.00 | 79.72 | 85.31 | 79.01 | 6.6833 | 8.46 |
| | Stnd Conc (mg/L) | | 72.00 | 79.72 | 85.31 | 79.01 | 6.6833 | 8.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn5 | BlnkCorr Signal | | 0.007 | 0.006 | 0.007 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 72.63 | 67.94 | 78.04 | 72.87 | 5.0543 | 6.94 |
| | Stnd Conc (mg/L) | | 72.63 | 67.94 | 78.04 | 72.87 | 5.0543 | 6.94 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn6 | BlnkCorr Signal | | 0.015 | 0.015 | 0.014 | 0.015 | 0.0006 | 3.85 |
| | sample conc (mg/L) | | 168.20 | 163.80 | 157.20 | 163.10 | 5.5365 | 3.39 |
| | Stnd Conc (mg/L) | | 168.20 | 163.80 | 157.20 | 163.10 | 5.5365 | 3.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn6 | BlnkCorr Signal | | 0.005 | 0.006 | 0.005 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 54.48 | 64.24 | 58.43 | 59.05 | 4.9095 | 8.31 |
| | Stnd Conc (mg/L) | | 54.48 | 64.24 | 58.43 | 59.05 | 4.9095 | 8.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn6 | BlnkCorr Signal | | 0.004 | 0.003 | 0.003 | 0.003 | 0.0006 | 19.25 |
| | sample conc (mg/L) | | 39.55 | 32.94 | 30.24 | 34.24 | 4.7899 | 13.99 |
| | Stnd Conc (mg/L) | | 39.55 | 32.94 | 30.24 | 34.24 | 4.7899 | 13.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn6 | BlnkCorr Signal | | 0.001 | 0.002 | 0.001 | 0.001 | 0.0006 | 57.74 |
| | sample conc (mg/L) | | 11.23 | 20.69 | 9.01 | 13.64 | 6.2020 | 45.47 |
| | Stnd Conc (mg/L) | | 11.23 | 20.69 | 9.01 | 13.64 | 6.2027 | 45.47 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M1 ReAn6 | BlnkCorr Signal | | 0.037 | 0.038 | 0.038 | 0.038 | 0.0006 | 1.52 |
| | sample conc (mg/L) | | 227.20 | 229.10 | 232.20 | 229.50 | 2.5239 | 1.10 |
| | Stnd Conc (mg/L) | | 227.20 | 229.10 | 232.20 | 229.50 | 2.5239 | 1.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M2 ReAn6 | BlnkCorr Signal | | 0.049 | 0.050 | 0.050 | 0.050 | 0.0006 | 1.15 |
| | sample conc (mg/L) | | 301.80 | 306.80 | 307.70 | 305.40 | 3.1786 | 1.04 |
| | Stnd Conc (mg/L) | | 301.80 | 306.80 | 307.70 | 305.40 | 3.1786 | 1.04 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M3 ReAn6 | BlnkCorr Signal | | 0.031 | 0.030 | 0.030 | 0.030 | 0.0006 | 1.92 |
| | sample conc (mg/L) | | 183.70 | 183.50 | 181.50 | 182.90 | 1.2166 | 0.67 |
| | Stnd Conc (mg/L) | | 183.70 | 183.50 | 181.50 | 182.90 | 1.2166 | 0.67 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M4 ReAn6 | BlnkCorr Signal | | 0.023 | 0.023 | 0.023 | 0.023 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 137.50 | 138.00 | 136.00 | 137.20 | 1.0408 | 0.76 |
| | Stnd Conc (mg/L) | | 137.50 | 138.00 | 136.00 | 137.20 | 1.0408 | 0.76 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M5 ReAn6 | BlnkCorr Signal | | 0.020 | 0.019 | 0.019 | 0.019 | 0.0006 | 3.04 |
| | sample conc (mg/L) | | 116.00 | 114.20 | 112.90 | 114.40 | 1.5567 | 1.36 |
| | Stnd Conc (mg/L) | | 116.00 | 114.20 | 112.90 | 114.40 | 1.5567 | 1.36 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M6 ReAn6 | BlnkCorr Signal | | 0.014 | 0.015 | 0.014 | 0.014 | 0.0006 | 4.12 |
| | sample conc (mg/L) | | 84.87 | 86.73 | 85.65 | 85.62 | 0.9340 | 1.09 |
| | Stnd Conc (mg/L) | | 84.87 | 86.73 | 85.65 | 85.62 | 0.9340 | 1.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M7 ReAn6 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 77.38 | 75.41 | 77.97 | 76.92 | 1.3406 | 1.74 |
| | Stnd Conc (mg/L) | | 77.38 | 75.41 | 77.97 | 76.92 | 1.3406 | 1.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M8 ReAn6 | BlnkCorr Signal | | 0.011 | 0.012 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 66.60 | 68.34 | 67.45 | 67.46 | 0.8701 | 1.29 |
| | Stnd Conc (mg/L) | | 66.60 | 68.34 | 67.45 | 67.46 | 0.8701 | 1.29 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M9 ReAn6 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 66.34 | 64.13 | 65.16 | 65.21 | 1.1058 | 1.70 |
| | Stnd Conc (mg/L) | | 66.34 | 64.13 | 65.16 | 65.21 | 1.1058 | 1.70 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M10 ReAn6 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 59.95 | 60.45 | 60.41 | 60.27 | 0.2778 | 0.46 |
| | Stnd Conc (mg/L) | | 59.95 | 60.45 | 60.41 | 60.27 | 0.2778 | 0.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M11 ReAn6 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 57.20 | 56.88 | 56.41 | 56.83 | 0.3974 | 0.70 |
| | Stnd Conc (mg/L) | | 57.20 | 56.88 | 56.41 | 56.83 | 0.3974 | 0.70 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M12 ReAn6 | BlnkCorr Signal | | 0.009 | 0.009 | 0.010 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 55.50 | 53.78 | 56.37 | 55.22 | 1.3180 | 2.39 |
| | Stnd Conc (mg/L) | | 55.50 | 53.78 | 56.37 | 55.22 | 1.3180 | 2.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M13 ReAn6 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.65 | 54.96 | 54.29 | 54.97 | 0.6800 | 1.24 |
| | Stnd Conc (mg/L) | | 55.65 | 54.96 | 54.29 | 54.97 | 0.6800 | 1.24 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M14 ReAn6 | BlnkCorr Signal | | 0.009 | 0.010 | 0.009 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 55.42 | 55.95 | 55.82 | 55.73 | 0.2762 | 0.50 |
| | Stnd Conc (mg/L) | | 55.42 | 55.95 | 55.82 | 55.73 | 0.2762 | 0.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 10g/L ReAn7 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 47.25 | 48.86 | 45.87 | 47.33 | 1.4965 | 3.16 |
| | Stnd Conc (mg/L) | | 47.25 | 48.86 | 45.87 | 47.33 | 1.4965 | 3.16 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn7 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 45.29 | 46.63 | 44.83 | 45.58 | 0.9352 | 2.05 |
| | Stnd Conc (mg/L) | | 45.29 | 46.63 | 44.83 | 45.58 | 0.9352 | 2.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn7 | BlnkCorr Signal | | 0.008 | 0.007 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 45.15 | 43.05 | 44.03 | 44.08 | 1.0508 | 2.38 |
| | Stnd Conc (mg/L) | | 45.15 | 43.05 | 44.03 | 44.08 | 1.0508 | 2.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn7 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 43.47 | 42.99 | 40.78 | 42.41 | 1.4347 | 3.38 |
| | Stnd Conc (mg/L) | | 43.47 | 42.99 | 40.78 | 42.41 | 1.4347 | 3.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 3g/L ReAn8 | BlnkCorr Signal | | 0.020 | 0.020 | 0.020 | 0.020 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 119.00 | 119.50 | 119.70 | 119.40 | 0.3606 | 0.30 |
| | Stnd Conc (mg/L) | | 119.00 | 119.50 | 119.70 | 119.40 | 0.3606 | 0.30 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 1 ReAn8 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 51.81 | 52.92 | 53.42 | 52.72 | 0.8240 | 1.56 |
| | Stnd Conc (mg/L) | | 51.81 | 52.92 | 53.42 | 52.72 | 0.8240 | 1.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 2 ReAn8 | BlnkCorr Signal | | 0.009 | 0.009 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 55.60 | 55.56 | 57.62 | 56.26 | 1.1780 | 2.09 |
| | Stnd Conc (mg/L) | | 55.60 | 55.56 | 57.62 | 56.26 | 1.1780 | 2.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 Wash 3 ReAn8 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 59.72 | 61.21 | 61.00 | 60.64 | 0.8067 | 1.33 |
| | Stnd Conc (mg/L) | | 59.72 | 61.21 | 61.00 | 60.64 | 0.8065 | 1.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M1 ReAn8 | BlnkCorr Signal | | 0.084 | 0.085 | 0.085 | 0.085 | 0.0006 | 0.68 |
| | sample conc (mg/L) | | 532.60 | 536.90 | 537.50 | 535.70 | 2.6727 | 0.50 |
| | Stnd Conc (mg/L) | | 532.60 | 536.90 | 537.50 | 535.70 | 2.6727 | 0.50 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M2 ReAn8 | BlnkCorr Signal | | 0.064 | 0.064 | 0.064 | 0.064 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 398.70 | 399.50 | 400.60 | 399.60 | 0.9539 | 0.24 |
| | Stnd Conc (mg/L) | | 398.70 | 399.50 | 400.60 | 399.60 | 0.9539 | 0.24 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M3 ReAn8 | BlnkCorr Signal | | 0.041 | 0.041 | 0.041 | 0.041 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 250.50 | 249.00 | 249.30 | 249.60 | 0.7937 | 0.32 |
| | Stnd Conc (mg/L) | | 250.50 | 249.00 | 249.30 | 249.60 | 0.7937 | 0.32 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T3 8M4 ReAn8 | BlnkCorr Signal | | 0.028 | 0.029 | 0.029 | 0.029 | 0.0006 | 1.99 |
| | sample conc (mg/L) | | 171.10 | 171.60 | 171.90 | 171.50 | 0.4041 | 0.24 |
| | Stnd Conc (mg/L) | | 171.10 | 171.60 | 171.90 | 171.50 | 0.4041 | 0.24 |

**XRF raw data - MIP Test 3**

| ID | Element | XRF % | concentration (mg/L) |
|---|---|---|---|
| Before Rinse | Ta | 2.95 | 29500 |
| | Sn | 0.029 | 290 |
| | W | 1.63 | 16300 |
| | Ti | 0.841 | 8410 |
| | Mn | 0.026 | 260 |
| | Bal | 93.55 | 935500 |
| | Sb | 0.015 | 150 |
| | Pd | 0.028 | 280 |
| | Rb | 0.003 | 30 |
| | Bi | 0.023 | 230 |
| | As | 0.095 | 950 |
| | Se | 0.094 | 940 |
| | **Re** | **0.603** | **6030** |
| | Co | 0.022 | 220 |
| | V | 0.65 | 6500 |
| After Rinse | Ta | 0.083 | 830 |
| | Nb | 0.276 | 2760 |
| | Sn | 0.004 | 40 |
| | Ti | 0.435 | 4350 |
| | Bal | 98.93 | 989300 |
| | Sb | 0.004 | 40 |
| | Mo | 0.046 | 460 |
| | Zr | 0.03 | 300 |
| | Sr | 0.005 | 50 |

| | | | |
|---|---|---|---|
| | Bi | 0.003 | 30 |
| | **Re** | **0.016** | **160** |
| | V | 0.312 | 3120 |
| 1M1 | Ta | 0.083 | 830 |
| | Nb | 0.278 | 2780 |
| | Sn | 0.004 | 40 |
| | Ti | 0.407 | 4070 |
| | Bal | 98.99 | 989900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.043 | 430 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.015** | **150** |
| | V | 0.281 | 2810 |
| 1M2 | Ta | 0.078 | 780 |
| | Nb | 0.258 | 2580 |
| | Sn | 0.004 | 40 |
| | Ti | 0.455 | 4550 |
| | Bal | 98.94 | 989400 |
| | Mo | 0.039 | 390 |
| | Zr | 0.027 | 270 |
| | Sr | 0.004 | 40 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.019** | **190** |
| | V | 0.303 | 3030 |
| 1M3 | Ta | 0.085 | 850 |
| | Nb | 0.265 | 2650 |
| | Sn | 0.003 | 30 |
| | Ti | 0.46 | 4600 |
| | Bal | 98.9 | 989000 |
| | Mo | 0.039 | 390 |
| | Zr | 0.028 | 280 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.019** | **190** |
| | V | 0.327 | 3270 |
| 1M4 | Ta | 0.083 | 830 |
| | Nb | 0.268 | 2680 |
| | Ti | 0.42 | 4200 |
| | Bal | 98.97 | 989700 |
| | Sb | 0.004 | 40 |
| | Mo | 0.041 | 410 |
| | Zr | 0.027 | 270 |
| | Sr | 0.004 | 40 |

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|---|---|---|---|
| | Bi | 0.002 | 20 |
| | **Re** | **0.014** | **140** |
| | V | 0.303 | 3030 |
| 1M5 | Ta | 0.089 | 890 |
| | Nb | 0.29 | 2900 |
| | Sn | 0.006 | 60 |
| | Ti | 0.482 | 4820 |
| | Fe | 0.015 | 150 |
| | Bal | 98.86 | 988600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.049 | 490 |
| | Zr | 0.033 | 330 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.01** | **100** |
| | V | 0.31 | 3100 |
| 3M1 | Ta | 0.076 | 760 |
| | Nb | 0.275 | 2750 |
| | Sn | 0.004 | 40 |
| | Ti | 0.454 | 4540 |
| | Bal | 98.92 | 989200 |
| | Sb | 0.004 | 40 |
| | Mo | 0.044 | 440 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.011** | **110** |
| | V | 0.315 | 3150 |
| 3M2 | Ta | 0.064 | 640 |
| | Nb | 0.198 | 1980 |
| | Ti | 0.322 | 3220 |
| | Bal | 99.19 | 991900 |
| | Mo | 0.027 | 270 |
| | Zr | 0.018 | 180 |
| | Sr | 0.002 | 20 |
| | **Re** | **0.011** | **110** |
| | V | 0.27 | 2700 |
| 3M3 | Ta | 0.061 | 610 |
| | Nb | 0.208 | 2080 |
| | Ti | 0.278 | 2780 |
| | Bal | 99.22 | 992200 |
| | Mo | 0.028 | 280 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |

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|---|---|---|---|
| | **Re** | **0.014** | **140** |
| | V | 0.27 | 2700 |
| 3M4 | Ta | 0.077 | 770 |
| | Nb | 0.228 | 2280 |
| | Sn | 0.004 | 40 |
| | Ti | 0.268 | 2680 |
| | Bal | 99.17 | 991700 |
| | Sb | 0.004 | 40 |
| | Mo | 0.036 | 360 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.019** | **190** |
| | V | 0.278 | 2780 |
| 3M5 | Ta | 0.073 | 730 |
| | Nb | 0.214 | 2140 |
| | Ti | 0.315 | 3150 |
| | Bal | 99.16 | 991600 |
| | Mo | 0.031 | 310 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.018** | **180** |
| | V | 0.272 | 2720 |
| 3M6 | Ta | 0.067 | 670 |
| | Nb | 0.23 | 2300 |
| | Sn | 0.005 | 50 |
| | Ti | 0.327 | 3270 |
| | Bal | 99.13 | 991300 |
| | Sb | 0.003 | 30 |
| | Mo | 0.035 | 350 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.018** | **180** |
| | V | 0.277 | 2770 |
| 3M7 | Ta | 0.075 | 750 |
| | Nb | 0.24 | 2400 |
| | Sn | 0.005 | 50 |
| | Ti | 0.369 | 3690 |
| | Fe | 0.022 | 220 |
| | Bal | 99.05 | 990500 |
| | Sb | 0.004 | 40 |
| | Mo | 0.037 | 370 |
| | Zr | 0.025 | 250 |

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|---|---|---|---|
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.017** | **170** |
| | V | 0.284 | 2840 |
| 3M8 | Ta | 0.078 | 780 |
| | Nb | 0.223 | 2230 |
| | Sn | 0.004 | 40 |
| | Ti | 0.341 | 3410 |
| | Fe | 0.008 | 80 |
| | Bal | 99.08 | 990800 |
| | Sb | 0.003 | 30 |
| | Mo | 0.034 | 340 |
| | Zr | 0.024 | 240 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.019** | **190** |
| | V | 0.298 | 2980 |
| 6M1 | Ta | 0.072 | 720 |
| | Nb | 0.201 | 2010 |
| | Sn | 0.003 | 30 |
| | Ti | 0.291 | 2910 |
| | Bal | 99.23 | 992300 |
| | Sb | 0.003 | 30 |
| | Mo | 0.027 | 270 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | **Re** | **0.015** | **150** |
| | V | 0.241 | 2410 |
| 6M2 | Ta | 0.057 | 570 |
| | Nb | 0.207 | 2070 |
| | Sn | 0.003 | 30 |
| | Ti | 0.385 | 3850 |
| | Bal | 99.13 | 991300 |
| | Sb | 0.004 | 40 |
| | Mo | 0.03 | 300 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.011** | **110** |
| | V | 0.249 | 2490 |
| 6M3 | Ta | 0.065 | 650 |
| | Nb | 0.201 | 2010 |
| | Sn | 0.003 | 30 |
| | Ti | 0.344 | 3440 |
| | Bal | 99.15 | 991500 |

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|---|---|---|---|
| | Sb | 0.002 | 20 |
| | Mo | 0.029 | 290 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.012** | **120** |
| | V | 0.275 | 2750 |
| 6M4 | Ta | 0.074 | 740 |
| | Nb | 0.201 | 2010 |
| | Ti | 0.349 | 3490 |
| | Bal | 99.13 | 991300 |
| | Mo | 0.028 | 280 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.009** | **90** |
| | V | 0.284 | 2840 |
| 6M5 | Ta | 0.08 | 800 |
| | Nb | 0.2 | 2000 |
| | Ti | 0.345 | 3450 |
| | Bal | 99.14 | 991400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.027 | 270 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.009** | **90** |
| | V | 0.276 | 2760 |
| 6M6 | Ta | 0.068 | 680 |
| | Nb | 0.199 | 1990 |
| | Sn | 0.003 | 30 |
| | Ti | 0.348 | 3480 |
| | Bal | 99.17 | 991700 |
| | Mo | 0.026 | 260 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.01** | **100** |
| | V | 0.261 | 2610 |
| 6M7 | Ta | 0.068 | 680 |
| | Nb | 0.196 | 1960 |
| | Ti | 0.306 | 3060 |
| | Bal | 99.2 | 992000 |
| | Sb | 0.002 | 20 |
| | Mo | 0.026 | 260 |

| | | | |
|---|---|---|---|
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.008** | **80** |
| | V | 0.266 | 2660 |
| 6M8 | Ta | 0.094 | 940 |
| | Nb | 0.205 | 2050 |
| | Ti | 0.334 | 3340 |
| | Bal | 99.12 | 991200 |
| | Sb | 0.003 | 30 |
| | Mo | 0.028 | 280 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.013** | **130** |
| | V | 0.294 | 2940 |
| 8M1 | Ta | 0.081 | 810 |
| | Nb | 0.186 | 1860 |
| | Ti | 0.289 | 2890 |
| | Fe | 0.009 | 90 |
| | Bal | 99.26 | 992600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.027 | 270 |
| | Zr | 0.017 | 170 |
| | Sr | 0.003 | 30 |
| | **Re** | **0.008** | **80** |
| | V | 0.219 | 2190 |
| 8M2 | Ta | 0.06 | 600 |
| | Nb | 0.19 | 1900 |
| | Sn | 0.003 | 30 |
| | Ti | 0.312 | 3120 |
| | Fe | 0.015 | 150 |
| | Bal | 99.19 | 991900 |
| | Mo | 0.026 | 260 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | V | 0.269 | 2690 |
| | **Re** | **0.003** | **30** |
| 8M3 | Ta | 0.076 | 760 |
| | Nb | 0.189 | 1890 |
| | Ti | 0.271 | 2710 |
| | Bal | 99.24 | 992400 |
| | Sb | 0.002 | 20 |
| | Mo | 0.025 | 250 |

| | | | |
|---|---|---|---|
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | Hf | 0.021 | 210 |
| | V | 0.248 | 2480 |
| | **Re** | **0.003** | **30** |
| 8M4 | Ta | 0.076 | 760 |
| | Nb | 0.177 | 1770 |
| | Sn | 0.003 | 30 |
| | Ti | 0.296 | 2960 |
| | Bal | 99.26 | 992600 |
| | Mo | 0.023 | 230 |
| | Zr | 0.016 | 160 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.005** | **50** |
| | V | 0.233 | 2330 |
| 8M5 | Ta | 0.086 | 860 |
| | Nb | 0.181 | 1810 |
| | Ti | 0.29 | 2900 |
| | Bal | 99.24 | 992400 |
| | Mo | 0.025 | 250 |
| | Zr | 0.017 | 170 |
| | Sr | 0.003 | 30 |
| | **Re** | **0.005** | **50** |
| | V | 0.253 | 2530 |
| 8M6 | Ta | 0.084 | 840 |
| | Nb | 0.188 | 1880 |
| | Sn | 0.003 | 30 |
| | Ti | 0.299 | 2990 |
| | Bal | 99.27 | 992700 |
| | Sb | 0.002 | 20 |
| | Mo | 0.025 | 250 |
| | Zr | 0.016 | 160 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | V | 0.213 | 2130 |
| | **Re** | **0.003** | **30** |
| 8M7 | Ta | 0.064 | 640 |
| | Nb | 0.186 | 1860 |
| | Ti | 0.336 | 3360 |
| | Bal | 99.24 | 992400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.023 | 230 |
| | Zr | 0.015 | 150 |

| | | | |
|---|---|---|---|
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | V | 0.227 | 2270 |
| | **Re** | **0.002** | **20** |
| 8M8 | Ta | 0.067 | 670 |
| | Nb | 0.18 | 1800 |
| | Ti | 0.294 | 2940 |
| | Bal | 99.24 | 992400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.024 | 240 |
| | Zr | 0.016 | 160 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | Hf | 0.02 | 200 |
| | V | 0.244 | 2440 |
| | **Re** | **0** | **0** |
| 3000mg/L $NH_4ReO_4$ addition | Ta | 0.194 | 1940 |
| | Nb | 0.256 | 2560 |
| | Sn | 0.004 | 40 |
| | Ti | 0.329 | 3290 |
| | Bal | 98.76 | 987600 |
| | Sb | 0.003 | 30 |
| | Mo | 0.041 | 410 |
| | Zr | 0.026 | 260 |
| | Sr | 0.004 | 40 |
| | Rb | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.275** | **2750** |
| | V | 0.269 | 2690 |
| Wash 1 | Ta | 0.221 | 2210 |
| | Nb | 0.267 | 2670 |
| | Sn | 0.004 | 40 |
| | Ti | 0.327 | 3270 |
| | Bal | 98.67 | 986700 |
| | Sb | 0.004 | 40 |
| | Mo | 0.043 | 430 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Rb | 0.002 | 20 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.342** | **3420** |
| | V | 0.259 | 2590 |
| Wash 2 | Ta | 0.209 | 2090 |
| | Nb | 0.264 | 2640 |
| | Sn | 0.003 | 30 |

| | | | |
|---|---|---|---|
| | Ti | 0.346 | 3460 |
| | Bal | 98.65 | 986500 |
| | Mo | 0.044 | 440 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.32** | **3200** |
| | V | 0.296 | 2960 |
| Wash 3 | Ta | 0.253 | 2530 |
| | Nb | 0.266 | 2660 |
| | Sn | 0.005 | 50 |
| | Ti | 0.345 | 3450 |
| | Bal | 98.61 | 986100 |
| | Sb | 0.003 | 30 |
| | Mo | 0.045 | 450 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.371** | **3710** |
| | V | 0.244 | 2440 |
| 6M1 A | Ta | 0.19 | 1900 |
| | Nb | 0.195 | 1950 |
| | Ti | 0.279 | 2790 |
| | Bal | 98.79 | 987900 |
| | Mo | 0.028 | 280 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.387** | **3870** |
| | V | 0.237 | 2370 |
| 6M2 A | Ta | 0.233 | 2330 |
| | Nb | 0.198 | 1980 |
| | Ti | 0.245 | 2450 |
| | Bal | 98.77 | 987700 |
| | Mo | 0.027 | 270 |
| | Zr | 0.017 | 170 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.002 | 20 |
| | **Re** | **0.46** | **4600** |
| | V | 0.19 | 1900 |
| 6M3 A | Ta | 0.234 | 2340 |
| | Nb | 0.192 | 1920 |
| | Ti | 0.258 | 2580 |
| | Bal | 98.65 | 986500 |

| | | | |
|---|---|---|---|
| | Mo | 0.027 | 270 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | As | 0.002 | 20 |
| | **Re** | **0.551** | **5510** |
| | V | 0.209 | 2090 |
| 6M4 A | Ta | 0.221 | 2210 |
| | Nb | 0.179 | 1790 |
| | Ti | 0.236 | 2360 |
| | Bal | 98.75 | 987500 |
| | Mo | 0.024 | 240 |
| | Zr | 0.016 | 160 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | As | 0.002 | 20 |
| | **Re** | **0.506** | **5060** |
| | V | 0.199 | 1990 |
| 6M5 A | Ta | 0.225 | 2250 |
| | Nb | 0.196 | 1960 |
| | Ti | 0.244 | 2440 |
| | Bal | 98.7 | 987000 |
| | Mo | 0.028 | 280 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.512** | **5120** |
| | V | 0.213 | 2130 |
| 6M6 A | Ta | 0.218 | 2180 |
| | Nb | 0.191 | 1910 |
| | Sn | 0.003 | 30 |
| | Ti | 0.218 | 2180 |
| | Bal | 98.79 | 987900 |
| | Mo | 0.028 | 280 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.478** | **4780** |
| | V | 0.188 | 1880 |
| 6M7 A | Ta | 0.19 | 1900 |
| | Nb | 0.192 | 1920 |
| | Ti | 0.295 | 2950 |
| | Bal | 98.73 | 987300 |
| | Mo | 0.027 | 270 |
| | Zr | 0.02 | 200 |

| | | | |
|---|---|---|---|
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.426** | **4260** |
| | V | 0.242 | 2420 |
| 6M8 A | Ta | 0.192 | 1920 |
| | Nb | 0.181 | 1810 |
| | Ti | 0.283 | 2830 |
| | Bal | 98.78 | 987800 |
| | Mo | 0.025 | 250 |
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.423** | **4230** |
| | V | 0.218 | 2180 |
| 6M9 A | Ta | 0.2 | 2000 |
| | Nb | 0.191 | 1910 |
| | Ti | 0.287 | 2870 |
| | Bal | 98.81 | 988100 |
| | Sb | 0.003 | 30 |
| | Mo | 0.026 | 260 |
| | Zr | 0.018 | 180 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.369** | **3690** |
| | V | 0.224 | 2240 |
| 6M10 A | Ta | 0.186 | 1860 |
| | Nb | 0.187 | 1870 |
| | Sn | 0.004 | 40 |
| | Ti | 0.227 | 2270 |
| | Bal | 98.93 | 989300 |
| | Sb | 0.003 | 30 |
| | Mo | 0.026 | 260 |
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.36** | **3600** |
| | V | 0.184 | 1840 |
| 6M11 A | Ta | 0.154 | 1540 |
| | Nb | 0.195 | 1950 |
| | Sn | 0.005 | 50 |
| | Ti | 0.318 | 3180 |
| | Bal | 98.89 | 988900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.028 | 280 |
| | Zr | 0.02 | 200 |

| | | | |
|---|---|---|---|
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.292** | **2920** |
| | V | 0.216 | 2160 |
| 6M12 A | Ta | 0.16 | 1600 |
| | Nb | 0.194 | 1940 |
| | Ti | 0.278 | 2780 |
| | Bal | 98.94 | 989400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.027 | 270 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.281** | **2810** |
| | V | 0.216 | 2160 |
| 6M13 A | Ta | 0.129 | 1290 |
| | Nb | 0.193 | 1930 |
| | Sn | 0.003 | 30 |
| | Ti | 0.285 | 2850 |
| | Bal | 98.95 | 989500 |
| | Mo | 0.025 | 250 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.26** | **2600** |
| | V | 0.243 | 2430 |
| 6M14 A | Ta | 0.154 | 1540 |
| | Nb | 0.187 | 1870 |
| | Sn | 0.004 | 40 |
| | Ti | 0.26 | 2600 |
| | Bal | 98.99 | 989900 |
| | Mo | 0.023 | 230 |
| | Zr | 0.016 | 160 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.259** | **2590** |
| | V | 0.22 | 2200 |
| 6M15 A | Ta | 0.119 | 1190 |
| | Nb | 0.192 | 1920 |
| | Ti | 0.28 | 2800 |
| | Bal | 99.01 | 990100 |
| | Mo | 0.026 | 260 |
| | Zr | 0.018 | 180 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |

| | | | |
|---|---|---|---|
| | **Re** | **0.231** | **2310** |
| | V | 0.235 | 2350 |
| 6M16 A | Ta | 0.135 | 1350 |
| | Nb | 0.183 | 1830 |
| | Ti | 0.292 | 2920 |
| | Bal | 99.01 | 990100 |
| | Mo | 0.025 | 250 |
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.199** | **1990** |
| | V | 0.246 | 2460 |
| 8M1 A | Bal | 99.87 | 998700 |
| | Ta | 0.042 | 420 |
| | **Re** | **0.09** | **900** |
| 8M2 A | Bal | 99.89 | 998900 |
| | Ta | 0.039 | 390 |
| | **Re** | **0.073** | **730** |
| 8M3 A | Bal | 99.9 | 999000 |
| | Ta | 0.035 | 350 |
| | **Re** | **0.06** | **600** |
| 8M4 A | Bal | 99.91 | 999100 |
| | Ta | 0.035 | 350 |
| | **Re** | **0.051** | **510** |
| 3000mg/L $NH_4ReO_4$ addition | Bal | 99.64 | 996400 |
| | Ta | 0.075 | 750 |
| | **Re** | **0.281** | **2810** |
| | Au | 0.002 | 20 |
| Wash 1 | Bal | 99.76 | 997600 |
| | Ta | 0.051 | 510 |
| | **Re** | **0.193** | **1930** |
| Wash 2 | Bal | 99.7 | 997000 |
| | Ta | 0.063 | 630 |
| | **Re** | **0.238** | **2380** |
| Wash 3 | Bal | 99.73 | 997300 |
| | Ta | 0.064 | 640 |
| | **Re** | **0.207** | **2070** |
| 3000mg/L $NH_4ReO_4$ addition (6000mg/L total) | Bal | 98.4 | 984000 |
| | As | 0.007 | 70 |
| | Ta | 0.182 | 1820 |
| | **Re** | **1.4** | **14000** |
| | Au | 0.012 | 120 |
| Wash 1 | Bal | 98.45 | 984500 |
| | As | 0.005 | 50 |
| | Ta | 0.157 | 1570 |

| | | | |
|---|---|---|---|
| | **Re** | **1.37** | **13700** |
| | Au | 0.01 | 100 |
| Wash 2 | Bal | 98.43 | 984300 |
| | As | 0.006 | 60 |
| | Ta | 0.157 | 1570 |
| | **Re** | **1.39** | **13900** |
| | Au | 0.011 | 110 |
| Wash 3 | Bal | 98.4 | 984000 |
| | As | 0.006 | 60 |
| | Ta | 0.155 | 1550 |
| | **Re** | **1.43** | **14300** |
| | Au | 0.009 | 90 |
| 3000mg/L $NH_4ReO_4$ addition (9000mg/L total) | Bal | 98.12 | 981200 |
| | As | 0.006 | 60 |
| | Ta | 0.17 | 1700 |
| | **Re** | **1.69** | **16900** |
| | Au | 0.011 | 110 |
| Wash 1 | Bal | 97.84 | 978400 |
| | As | 0.008 | 80 |
| | Ta | 0.217 | 2170 |
| | **Re** | **1.92** | **19200** |
| | Au | 0.014 | 140 |
| Wash 2 | Bal | 97.88 | 978800 |
| | As | 0.008 | 80 |
| | Ta | 0.18 | 1800 |
| | **Re** | **1.82** | **18200** |
| | Au | 0.012 | 120 |
| Wash 3 | Bal | 97.8 | 978000 |
| | As | 0.008 | 80 |
| | Ta | 0.218 | 2180 |
| | **Re** | **1.97** | **19700** |
| | Au | 0.012 | 120 |
| 8M1 A | Bal | 98.79 | 987900 |
| | As | 0.007 | 70 |
| | Ta | 0.17 | 1700 |
| | **Re** | **1.02** | **10200** |
| | Au | 0.01 | 100 |
| 8M2 A | Bal | 99.07 | 990700 |
| | As | 0.005 | 50 |
| | Ta | 0.127 | 1270 |
| | **Re** | **0.787** | **7870** |
| | Au | 0.008 | 80 |
| 8M3 A | Bal | 99.28 | 992800 |
| | As | 0.004 | 40 |
| | Ta | 0.109 | 1090 |

| | | | |
|---|---|---|---|
| | **Re** | **0.596** | **5960** |
| | Au | 0.007 | 70 |
| 8M4 A | Bal | 99.46 | 994600 |
| | As | 0.003 | 30 |
| | Ta | 0.084 | 840 |
| | **Re** | **0.447** | **4470** |
| | Au | 0.004 | 40 |
| 8M5 A | Bal | 99.58 | 995800 |
| | As | 0.002 | 20 |
| | Ta | 0.08 | 800 |
| | **Re** | **0.332** | **3320** |
| | Au | 0.003 | 30 |
| 8M6 A | Bal | 99.66 | 996600 |
| | As | 0.002 | 20 |
| | Ta | 0.07 | 700 |
| | **Re** | **0.267** | **2670** |
| | Au | 0.002 | 20 |
| 8M7 A | Bal | 99.72 | 997200 |
| | Ta | 0.056 | 560 |
| | **Re** | **0.219** | **2190** |
| 8M8 A | Bal | 99.78 | 997800 |
| | Ta | 0.048 | 480 |
| | **Re** | **0.174** | **1740** |
| 8M9 A | Bal | 99.78 | 997800 |
| | Ta | 0.053 | 530 |
| | **Re** | **0.163** | **1630** |
| 8M10 A | Bal | 99.82 | 998200 |
| | Ta | 0.048 | 480 |
| | **Re** | **0.132** | **1320** |
| 8M11 A | Bal | 99.85 | 998500 |
| | Ta | 0.042 | 420 |
| | **Re** | **0.103** | **1030** |
| 8M12 A | Bal | 99.87 | 998700 |
| | Ta | 0.037 | 370 |
| | **Re** | **0.096** | **960** |
| 3000mg/L $NH_4ReO_4$ addition | Bal | 99.59 | 995900 |
| | Ta | 0.082 | 820 |
| | **Re** | **0.325** | **3250** |
| | Au | 0.002 | 20 |
| Wash 1 | Bal | 99.52 | 995200 |
| | As | 0.002 | 20 |
| | Ta | 0.092 | 920 |
| | **Re** | **0.382** | **3820** |
| | Au | 0.002 | 20 |

| | | | |
|---|---|---|---|
| Wash 2 | Bal | 99.47 | 994700 |
| | As | 0.002 | 20 |
| | Ta | 0.095 | 950 |
| | **Re** | **0.433** | **4330** |
| | Au | 0.002 | 20 |
| Wash 3 | Bal | 99.47 | 994700 |
| | As | 0.002 | 20 |
| | Ta | 0.096 | 960 |
| | **Re** | **0.429** | **4290** |
| | Au | 0.003 | 30 |
| 3000mg/L $NH_4ReO_4$ addition (6000mg/L total) | Bal | 98.41 | 984100 |
| | As | 0.005 | 50 |
| | Ta | 0.158 | 1580 |
| | **Re** | **1.42** | **14200** |
| | Au | 0.009 | 90 |
| Wash 1 | Bal | 98.32 | 983200 |
| | As | 0.006 | 60 |
| | Ta | 0.171 | 1710 |
| | **Re** | **1.5** | **15000** |
| | Au | 0.011 | 110 |
| Wash 2 | Bal | 98.14 | 981400 |
| | As | 0.008 | 80 |
| | Ta | 0.209 | 2090 |
| | **Re** | **1.63** | **16300** |
| | Au | 0.011 | 110 |
| Wash 3 | Bal | 98.12 | 981200 |
| | As | 0.007 | 70 |
| | Ta | 0.194 | 1940 |
| | **Re** | **1.66** | **16600** |
| | Au | 0.01 | 100 |
| 3000mg/L $NH_4ReO_4$ addition (9000mg/L total) | Bal | 97.59 | 975900 |
| | As | 0.01 | 100 |
| | Ta | 0.235 | 2350 |
| | **Re** | **2.16** | **21600** |
| | Au | 0.013 | 130 |
| Wash 1 | Bal | 97.71 | 977100 |
| | As | 0.008 | 80 |
| | Ta | 0.222 | 2220 |
| | **Re** | **2.04** | **20400** |
| | Au | 0.013 | 130 |
| Wash 2 | Bal | 97.75 | 977500 |
| | As | 0.008 | 80 |
| | Ta | 0.203 | 2030 |
| | **Re** | **2.03** | **20300** |
| | Au | 0.012 | 120 |

| | | | |
|---|---|---|---|
| Wash 3 | Bal | 97.61 | 976100 |
| | As | 0.008 | 80 |
| | Ta | 0.211 | 2110 |
| | **Re** | **2.16** | **21600** |
| | Au | 0.011 | 110 |
| 8M1 A | Bal | 98.72 | 987200 |
| | As | 0.007 | 70 |
| | Ta | 0.182 | 1820 |
| | **Re** | **1.08** | **10800** |
| | Au | 0.011 | 110 |
| 8M2 A | Bal | 98.99 | 989900 |
| | As | 0.006 | 60 |
| | Ta | 0.147 | 1470 |
| | **Re** | **0.85** | **8500** |
| | Au | 0.008 | 80 |
| 8M3 A | Bal | 99.19 | 991900 |
| | As | 0.004 | 40 |
| | Ta | 0.128 | 1280 |
| | **Re** | **0.667** | **6670** |
| | Au | 0.007 | 70 |
| 8M4 A | Bal | 99.4 | 994000 |
| | As | 0.003 | 30 |
| | Ta | 0.087 | 870 |
| | **Re** | **0.504** | **5040** |
| | Au | 0.004 | 40 |
| 8M5 A | Bal | 99.49 | 994900 |
| | As | 0.002 | 20 |
| | Ta | 0.08 | 800 |
| | **Re** | **0.421** | **4210** |
| | Au | 0.004 | 40 |
| 8M6 A | Bal | 99.55 | 995500 |
| | As | 0.002 | 20 |
| | Ta | 0.076 | 760 |
| | **Re** | **0.367** | **3670** |
| | Au | 0.004 | 40 |
| 8M7 A | Bal | 99.61 | 996100 |
| | Ta | 0.071 | 710 |
| | **Re** | **0.318** | **3180** |
| | Au | 0.002 | 20 |
| 8M8 A | Bal | 99.63 | 996300 |
| | Ta | 0.067 | 670 |
| | **Re** | **0.294** | **2940** |
| | Au | 0.003 | 30 |
| 8M9 A | Bal | 99.75 | 997500 |
| | Ta | 0.044 | 440 |

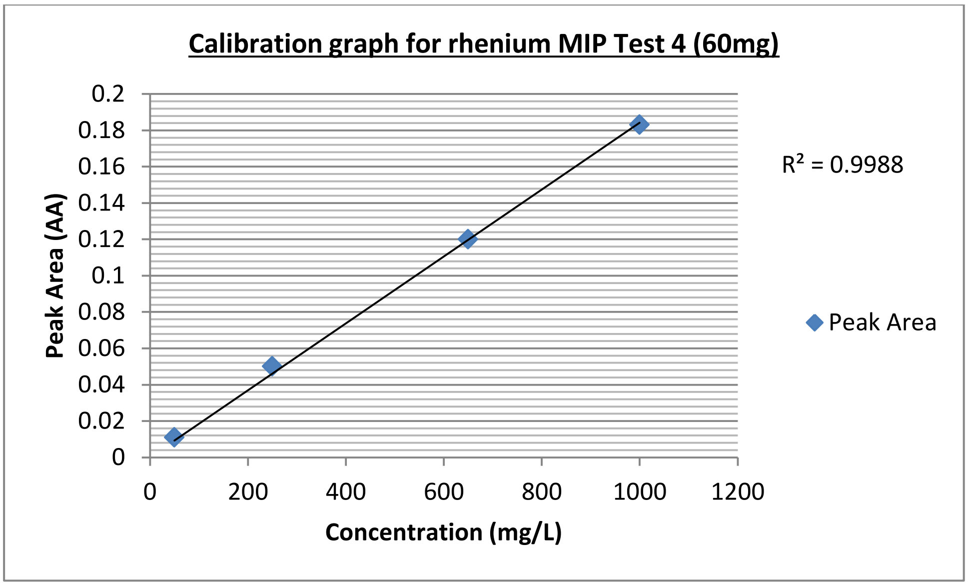
| | | | |
|---|---|---|---|
| | **Re** | **0.206** | **2060** |
| 8M10 A | Bal | 99.75 | 997500 |
| | Ta | 0.054 | 540 |
| | **Re** | **0.193** | **1930** |
| 8M11 A | Bal | 99.76 | 997600 |
| | Ta | 0.046 | 460 |
| | **Re** | **0.19** | **1900** |
| 8M12 A | Bal | 99.77 | 997700 |
| | Ta | 0.048 | 480 |
| | **Re** | **0.183** | **1830** |
| 8M13 A | Bal | 99.85 | 998500 |
| | Ta | 0.037 | 370 |
| | **Re** | **0.117** | **1170** |
| 8M14 A | Bal | 99.85 | 998500 |
| | Ta | 0.04 | 400 |
| | **Re** | **0.11** | **1100** |
| 10,000mg/L $NH_4ReO_4$ addition | Bal | 98.42 | 984200 |
| | As | 0.006 | 60 |
| | Ta | 0.206 | 2060 |
| | **Re** | **1.36** | **13600** |
| | Au | 0.007 | 70 |
| Wash 1 | Bal | 98.07 | 980700 |
| | As | 0.009 | 90 |
| | Ta | 0.236 | 2360 |
| | **Re** | **1.68** | **16800** |
| | Au | 0.008 | 80 |
| Wash 2 | Bal | 98.15 | 981500 |
| | As | 0.008 | 80 |
| | Ta | 0.227 | 2270 |
| | **Re** | **1.61** | **16100** |
| | Au | 0.008 | 80 |
| Wash 3 | Bal | 97.83 | 978300 |
| | As | 0.009 | 90 |
| | Ta | 0.244 | 2440 |
| | **Re** | **1.91** | **19100** |
| | Au | 0.011 | 110 |
| 3000mg/L $NH_4ReO_4$ addition (13000mg/L total) | Bal | 97.12 | 971200 |
| | As | 0.012 | 120 |
| | Zr | 0.002 | 20 |
| | Ta | 0.302 | 3020 |
| | **Re** | **2.55** | **25500** |
| | Au | 0.013 | 130 |
| Wash 1 | Bal | 97.14 | 971400 |
| | As | 0.01 | 100 |
| | Ta | 0.27 | 2700 |

| | | | |
|---|---|---|---|
| | **Re** | **2.57** | **25700** |
| | Au | 0.011 | 110 |
| Wash 2 | Bal | 97.09 | 970900 |
| | As | 0.009 | 90 |
| | Ta | 0.267 | 2670 |
| | **Re** | **2.63** | **26300** |
| | Au | 0.01 | 100 |
| Wash 3 | Bal | 97.08 | 970800 |
| | As | 0.011 | 110 |
| | Ta | 0.266 | 2660 |
| | **Re** | **2.63** | **26300** |
| | Au | 0.012 | 120 |
| 8M1 A | Bal | 98.34 | 983400 |
| | As | 0.008 | 80 |
| | Ta | 0.215 | 2150 |
| | **Re** | **1.42** | **14200** |
| | Au | 0.013 | 130 |
| 8M2 A | Bal | 98.74 | 987400 |
| | As | 0.007 | 70 |
| | Ta | 0.187 | 1870 |
| | **Re** | **1.06** | **10600** |
| | Au | 0.01 | 100 |
| 8M3 A | Bal | 99.02 | 990200 |
| | As | 0.006 | 60 |
| | Ta | 0.136 | 1360 |
| | **Re** | **0.827** | **8270** |
| | Au | 0.008 | 80 |
| 8M4 A | Bal | 99.21 | 992100 |
| | As | 0.005 | 50 |
| | Ta | 0.116 | 1160 |
| | **Re** | **0.666** | **6660** |
| | Au | 0.006 | 60 |

### 7.15. Appendix 15 - MIP Test 4 Calibration graph; XRF and AAS raw data

range: 50 - 1000ppm (mg/L)

| Concentration (ppm) | BlnkCorr (PA) | Average | SD | RSD% |
|---|---|---|---|---|
| blank | 0.665 | 0.665 | 0.00000 | 0.00 |
| | 0.665 | | | |
| | 0.665 | | | |
| 50 | 0.010 | 0.011 | 0.00058 | 5.25 |
| | 0.011 | | | |
| | 0.011 | | | |
| 250 | 0.050 | 0.050 | 0.00000 | 0.00 |
| | 0.050 | | | |
| | 0.050 | | | |
| 650 | 0.120 | 0.120 | 0.00000 | 0.00 |
| | 0.120 | | | |
| | 0.120 | | | |
| 1000 | 0.183 | 0.183 | 0.00100 | 0.55 |
| | 0.182 | | | |
| | 0.184 | | | |




## AAS raw data - MIP test 4

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 A.R | BlnkCorr Signal | | -0.011 | -0.010 | -0.010 | -0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | -48.86 | -47.71 | -46.52 | -47.70 | 1.1701 | 2.45 |
| | Stnd Conc (mg/L) | | -48.86 | -47.71 | -46.52 | -47.70 | 1.1701 | 2.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 1M1 | BlnkCorr Signal | | -0.018 | -0.016 | -0.016 | -0.017 | 0.0012 | 6.79 |
| | sample conc (mg/L) | | -79.53 | -74.09 | -71.31 | -74.98 | 4.1811 | 5.58 |
| | Stnd Conc (mg/L) | | -79.53 | -74.09 | -71.31 | -74.98 | 4.1811 | 5.58 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 1M2 | BlnkCorr Signal | | -0.019 | -0.019 | -0.018 | -0.019 | 0.0006 | 3.04 |
| | sample conc (mg/L) | | -86.22 | -84.15 | -81.53 | -83.96 | 2.3504 | 2.80 |
| | Stnd Conc (mg/L) | | -86.22 | -84.15 | -81.53 | -83.96 | 2.3504 | 2.80 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 1M3 | BlnkCorr Signal | | -0.022 | -0.022 | -0.022 | -0.022 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | -95.51 | -97.96 | -95.60 | -96.35 | 1.3893 | 1.44 |
| | Stnd Conc (mg/L) | | -95.51 | -97.96 | -95.60 | -96.35 | 1.3893 | 1.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 1M4 | BlnkCorr Signal | | -0.022 | -0.023 | -0.023 | -0.023 | 0.0006 | 2.51 |
| | sample conc (mg/L) | | -97.84 | -101.00 | -99.69 | -99.41 | 1.5877 | 1.60 |
| | Stnd Conc (mg/L) | | -97.84 | -101.00 | -99.69 | -99.41 | 1.5877 | 1.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 1M5 | BlnkCorr Signal | | -0.027 | -0.028 | -0.026 | -0.027 | 0.0010 | 3.70 |
| | sample conc (mg/L) | | -116.90 | -118.90 | -110.90 | -115.60 | 4.1633 | 3.60 |
| | Stnd Conc (mg/L) | | -116.90 | -118.90 | -110.90 | -115.60 | 4.1633 | 3.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M1 | BlnkCorr Signal | | -0.025 | -0.026 | -0.029 | -0.027 | 0.0021 | 7.71 |
| | sample conc (mg/L) | | -109.60 | -114.20 | -122.60 | -115.50 | 6.5919 | 5.71 |
| | Stnd Conc (mg/L) | | -109.60 | -114.20 | -122.60 | -115.50 | 6.5919 | 5.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M2 | BlnkCorr Signal | | 0.010 | 0.009 | 0.010 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 47.64 | 45.37 | 47.50 | 46.84 | 1.2721 | 2.72 |
| | Stnd Conc (mg/L) | | 47.64 | 45.37 | 47.50 | 46.84 | 1.2721 | 2.72 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M3 | BlnkCorr Signal | | -0.002 | -0.003 | -0.002 | -0.002 | 0.0006 | 28.87 |
| | sample conc (mg/L) | | -7.71 | -13.44 | -11.13 | -10.76 | 2.8834 | 26.80 |
| | Stnd Conc (mg/L) | | -7.71 | -13.44 | -11.13 | -10.76 | 2.8834 | 26.80 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M4 | BlnkCorr Signal | | 0.013 | 0.012 | 0.012 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 57.61 | 56.89 | 55.31 | 55.60 | 1.1765 | 2.12 |
| | Stnd Conc (mg/L) | | 57.61 | 56.89 | 55.31 | 55.60 | 1.1765 | 2.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M5 | BlnkCorr Signal | | 0.018 | 0.018 | 0.019 | 0.019 | 0.0006 | 3.04 |
| | sample conc (mg/L) | | 88.24 | 85.77 | 92.80 | 88.94 | 3.5664 | 4.01 |
| | Stnd Conc (mg/L) | | 88.24 | 85.77 | 92.80 | 88.94 | 3.5664 | 4.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M6 | BlnkCorr Signal | | 0.021 | 0.022 | 0.020 | 0.021 | 0.0010 | 4.76 |
| | sample conc (mg/L) | | 102.00 | 105.10 | 96.06 | 101.00 | 4.5937 | 4.55 |
| | Stnd Conc (mg/L) | | 102.00 | 105.10 | 96.06 | 101.00 | 4.5937 | 4.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M7 | BlnkCorr Signal | | 0.022 | 0.022 | 0.021 | 0.022 | 0.0006 | 2.62 |
| | sample conc (mg/L) | | 107.50 | 105.10 | 102.50 | 105.00 | 2.5007 | 2.38 |
| | Stnd Conc (mg/L) | | 107.50 | 105.10 | 102.50 | 105.00 | 2.5007 | 2.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3M8 | BlnkCorr Signal | | 0.022 | 0.023 | 0.020 | 0.022 | 0.0015 | 6.94 |
| | sample conc (mg/L) | | 106.00 | 111.80 | 98.94 | 105.60 | 6.4403 | 6.10 |
| | Stnd Conc (mg/L) | | 106.00 | 111.80 | 98.94 | 105.60 | 6.4403 | 6.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M1 | BlnkCorr Signal | | 0.020 | 0.020 | 0.019 | 0.020 | 0.0006 | 2.89 |
| | sample conc (mg/L) | | 95.68 | 95.29 | 91.12 | 94.03 | 2.5277 | 2.69 |
| | Stnd Conc (mg/L) | | 95.68 | 95.29 | 91.12 | 94.03 | 2.5277 | 2.69 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M2 | BlnkCorr Signal | | 0.019 | 0.019 | 0.019 | 0.019 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 90.87 | 90.91 | 93.65 | 91.81 | 1.5936 | 1.74 |
| | Stnd Conc (mg/L) | | 90.87 | 90.91 | 93.65 | 91.81 | 1.5936 | 1.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M3 | BlnkCorr Signal | | 0.018 | 0.019 | 0.018 | 0.018 | 0.0006 | 3.21 |
| | sample conc (mg/L) | | 84.45 | 89.05 | 84.34 | 85.94 | 2.6881 | 3.13 |
| | Stnd Conc (mg/L) | | 84.45 | 89.05 | 84.34 | 85.94 | 2.6881 | 3.13 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M4 | BlnkCorr Signal | | 0.019 | 0.019 | 0.019 | 0.019 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 110.30 | 112.30 | 115.30 | 112.60 | 2.5166 | 2.24 |
| | Stnd Conc (mg/L) | | 110.30 | 112.30 | 115.30 | 112.60 | 2.5166 | 2.24 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M5 | BlnkCorr Signal | | 0.024 | 0.023 | 0.024 | 0.024 | 0.0006 | 2.41 |
| | sample conc (mg/L) | | 145.40 | 139.50 | 147.80 | 144.20 | 4.2712 | 2.96 |
| | Stnd Conc (mg/L) | | 145.40 | 139.50 | 147.80 | 144.20 | 4.2712 | 2.96 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M6 | BlnkCorr Signal | | 0.026 | 0.026 | 0.026 | 0.026 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 159.30 | 155.80 | 159.30 | 158.10 | 2.0207 | 1.28 |
| | Stnd Conc (mg/L) | | 159.30 | 155.80 | 159.30 | 158.10 | 2.0207 | 1.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M7 | BlnkCorr Signal | | 0.027 | 0.028 | 0.029 | 0.028 | 0.0010 | 3.57 |
| | sample conc (mg/L) | | 166.00 | 170.90 | 175.60 | 170.90 | 4.8003 | 2.81 |
| | Stnd Conc (mg/L) | | 166.00 | 170.90 | 175.60 | 170.90 | 4.8003 | 2.81 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 6M8 | BlnkCorr Signal | | 0.028 | 0.029 | 0.029 | 0.029 | 0.0006 | 1.99 |
| | sample conc (mg/L) | | 173.90 | 175.00 | 178.50 | 175.80 | 2.4021 | 1.37 |
| | Stnd Conc (mg/L) | | 173.90 | 175.00 | 178.50 | 175.80 | 2.4021 | 1.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M1 | BlnkCorr Signal | | 0.028 | 0.029 | 0.027 | 0.028 | 0.0010 | 3.57 |
| | sample conc (mg/L) | | 170.20 | 177.60 | 167.60 | 171.80 | 5.1884 | 3.02 |
| | Stnd Conc (mg/L) | | 170.20 | 177.60 | 167.60 | 171.80 | 5.1884 | 3.02 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M2 | BlnkCorr Signal | | 0.028 | 0.027 | 0.028 | 0.027 | 0.0006 | 2.14 |
| | sample conc (mg/L) | | 169.50 | 165.80 | 168.20 | 167.90 | 1.8771 | 1.12 |
| | Stnd Conc (mg/L) | | 169.50 | 165.80 | 168.20 | 167.90 | 1.8771 | 1.12 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M3 | BlnkCorr Signal | | 0.026 | 0.026 | 0.026 | 0.026 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 159.00 | 161.10 | 156.00 | 158.70 | 2.5632 | 1.62 |
| | Stnd Conc (mg/L) | | 159.00 | 161.10 | 156.00 | 158.70 | 2.5632 | 1.62 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M4 | BlnkCorr Signal | | 0.025 | 0.025 | 0.024 | 0.025 | 0.0006 | 2.31 |
| | sample conc (mg/L) | | 152.90 | 151.80 | 147.90 | 150.90 | 2.6274 | 1.74 |
| | Stnd Conc (mg/L) | | 152.90 | 151.80 | 147.90 | 150.90 | 2.6274 | 1.74 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M5 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 70.62 | 74.65 | 71.52 | 72.26 | 2.1153 | 2.93 |
| | Stnd Conc (mg/L) | | 70.62 | 74.65 | 71.52 | 72.26 | 2.1153 | 2.93 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M6 | BlnkCorr Signal | | 0.012 | 0.013 | 0.012 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 84.35 | 86.42 | 85.10 | 85.29 | 1.0480 | 1.23 |
| | Stnd Conc (mg/L) | | 84.35 | 86.42 | 85.10 | 85.29 | 1.0480 | 1.23 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M7 | BlnkCorr Signal | | 0.013 | 0.014 | 0.014 | 0.014 | 0.0006 | 4.12 |
| | sample conc (mg/L) | | 90.68 | 95.10 | 91.98 | 92.58 | 2.2716 | 2.45 |
| | Stnd Conc (mg/L) | | 90.68 | 95.10 | 91.98 | 92.58 | 2.2716 | 2.45 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M8 | BlnkCorr Signal | | 0.014 | 0.015 | 0.014 | 0.014 | 0.0006 | 4.12 |
| | sample conc (mg/L) | | 99.31 | 103.60 | 94.56 | 99.14 | 4.5220 | 4.56 |
| | Stnd Conc (mg/L) | | 99.31 | 103.60 | 94.56 | 99.14 | 4.5220 | 4.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3g/L ReAn | BlnkCorr Signal | | 0.014 | 0.012 | 0.013 | 0.013 | 0.0010 | 7.69 |
| | sample conc (mg/L) | | 96.03 | 65.52 | 93.21 | 91.59 | 16.8600 | 18.41 |
| | Stnd Conc (mg/L) | | 96.03 | 65.52 | 93.21 | 91.59 | 16.8600 | 18.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 1 ReAn | BlnkCorr Signal | | 0.012 | 0.013 | 0.013 | 0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | 83.82 | 90.81 | 87.85 | 87.50 | 3.5086 | 4.01 |
| | Stnd Conc (mg/L) | | 83.82 | 90.81 | 87.85 | 87.50 | 3.5086 | 4.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 2 ReAn | BlnkCorr Signal | | 0.013 | 0.012 | 0.012 | 0.012 | 0.0006 | 4.81 |
| | sample conc (mg/L) | | 87.48 | 83.64 | 82.92 | 84.68 | 2.4514 | 2.89 |
| | Stnd Conc (mg/L) | | 87.48 | 83.64 | 82.92 | 84.68 | 2.4514 | 2.89 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 3 ReAn | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 68.73 | 72.46 | 70.71 | 70.63 | 1.8662 | 2.64 |
| | Stnd Conc (mg/L) | | 68.73 | 72.46 | 70.71 | 70.63 | 1.8662 | 2.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M1 ReAn | BlnkCorr Signal | | 0.007 | 0.008 | 0.008 | 0.008 | 0.0006 | 7.22 |
| | sample conc (mg/L) | | 34.49 | 35.26 | 35.77 | 35.17 | 0.6444 | 1.83 |
| | Stnd Conc (mg/L) | | 34.49 | 35.26 | 35.77 | 35.17 | 0.6444 | 1.83 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M2 ReAn | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 45.70 | 45.88 | 45.12 | 45.56 | 0.3972 | 0.87 |
| | Stnd Conc (mg/L) | | 45.70 | 45.88 | 45.12 | 45.56 | 0.3972 | 0.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M3 ReAn | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 37.32 | 37.09 | 37.83 | 37.42 | 0.3787 | 1.01 |
| | Stnd Conc (mg/L) | | 37.32 | 37.09 | 37.83 | 37.42 | 0.3787 | 1.01 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M4 ReAn | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 33.08 | 33.61 | 33.54 | 33.41 | 0.2879 | 0.86 |
| | Stnd Conc (mg/L) | | 33.08 | 33.61 | 33.54 | 33.41 | 0.2879 | 0.86 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M5 ReAn | BlnkCorr Signal | | 0.007 | 0.006 | 0.007 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 30.83 | 29.82 | 31.90 | 30.85 | 1.0401 | 3.37 |
| | Stnd Conc (mg/L) | | 30.83 | 29.82 | 31.90 | 30.85 | 1.0401 | 3.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M6 ReAn | BlnkCorr Signal | | 0.006 | 0.007 | 0.006 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 29.68 | 31.23 | 28.74 | 29.88 | 1.2574 | 4.21 |
| | Stnd Conc (mg/L) | | 229.68 | 31.23 | 28.74 | 29.88 | 115.3007 | 385.88 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M7 ReAn | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 29.00 | 29.40 | 30.03 | 29.47 | 0.5193 | 1.76 |
| | Stnd Conc (mg/L) | | 29.00 | 29.40 | 30.03 | 29.47 | 0.5193 | 1.76 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M8 ReAn | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 29.34 | 29.63 | 30.03 | 29.68 | 0.3474 | 1.17 |
| | Stnd Conc (mg/L) | | 29.34 | 29.63 | 30.03 | 29.68 | 0.3465 | 1.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M9 ReAn | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 29.43 | 30.16 | 29.57 | 29.72 | 0.3874 | 1.30 |
| | Stnd Conc (mg/L) | | 29.43 | 30.16 | 29.57 | 29.72 | 0.3874 | 1.30 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M10 ReAn | BlnkCorr Signal | | 0.007 | 0.006 | 0.006 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 31.88 | 30.04 | 28.50 | 30.14 | 1.6922 | 5.61 |
| | Stnd Conc (mg/L) | | 31.88 | 30.04 | 28.50 | 30.14 | 1.6922 | 5.61 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M11 ReAn | BlnkCorr Signal | | 0.006 | 0.007 | 0.006 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 28.91 | 30.74 | 29.62 | 29.76 | 0.9226 | 3.10 |
| | Stnd Conc (mg/L) | | 28.91 | 30.74 | 29.62 | 29.76 | 0.9226 | 3.10 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M12 ReAn | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 28.99 | 29.42 | 29.72 | 29.38 | 0.3669 | 1.25 |
| | Stnd Conc (mg/L) | | 28.99 | 29.42 | 29.72 | 29.38 | 0.3669 | 1.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3g/L ReAn1 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 25.23 | 24.12 | 24.38 | 24.58 | 0.5805 | 2.36 |
| | Stnd Conc (mg/L) | | 25.23 | 24.12 | 24.38 | 24.58 | 0.5805 | 2.36 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 1 ReAn1 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 24.56 | 24.63 | 23.34 | 24.28 | 0.7254 | 2.99 |
| | Stnd Conc (mg/L) | | 24.56 | 24.63 | 23.34 | 24.28 | 0.7254 | 2.99 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 2 ReAn1 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 24.37 | 24.27 | 22.97 | 23.87 | 0.7810 | 3.27 |
| | Stnd Conc (mg/L) | | 24.37 | 24.27 | 22.97 | 23.87 | 0.7810 | 3.27 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 3 ReAn1 | BlnkCorr Signal | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 23.56 | 23.56 | 24.07 | 23.73 | 0.2944 | 1.24 |
| | Stnd Conc (mg/L) | 23.56 | 23.56 | 24.07 | 23.73 | 0.2956 | 1.25 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 3g/L ReAn2 | BlnkCorr Signal | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 37.31 | 37.18 | 37.25 | 37.25 | 0.0651 | 0.17 |
| | Stnd Conc (mg/L) | 37.31 | 37.18 | 37.25 | 37.25 | 0.0651 | 0.17 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 1 ReAn2 | BlnkCorr Signal | 0.006 | 0.005 | 0.005 | 0.005 | 0.0006 | 11.55 |
| | sample conc (mg/L) | 26.35 | 24.58 | 24.93 | 25.29 | 0.9374 | 3.71 |
| | Stnd Conc (mg/L) | 26.35 | 24.58 | 24.93 | 25.29 | 0.9374 | 3.71 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 2 ReAn2 | BlnkCorr Signal | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 23.19 | 24.53 | 24.62 | 24.11 | 0.8009 | 3.32 |
| | Stnd Conc (mg/L) | 23.19 | 24.53 | 24.62 | 24.11 | 0.8009 | 3.32 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 3 ReAn1 | BlnkCorr Signal | 0.005 | 0.006 | 0.005 | 0.005 | 0.0006 | 11.55 |
| | sample conc (mg/L) | 23.35 | 26.01 | 24.63 | 24.67 | 1.3303 | 5.39 |
| | Stnd Conc (mg/L) | 23.35 | 26.01 | 24.63 | 24.67 | 1.3303 | 5.39 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 3g/L ReAn3 | BlnkCorr Signal | 0.019 | 0.019 | 0.019 | 0.019 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 92.23 | 91.32 | 91.31 | 91.62 | 0.5283 | 0.58 |
| | Stnd Conc (mg/L) | 92.23 | 91.32 | 91.31 | 91.62 | 0.5283 | 0.58 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 1 ReAn3 | BlnkCorr Signal | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 28.63 | 29.18 | 29.12 | 29.98 | 0.3017 | 1.01 |
| | Stnd Conc (mg/L) | 28.63 | 29.18 | 29.12 | 29.98 | 0.3017 | 1.01 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash2 ReAn3 | BlnkCorr Signal | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 29.28 | 29.22 | 27.85 | 28.78 | 0.8088 | 2.81 |
| | Stnd Conc (mg/L) | 29.28 | 29.22 | 27.85 | 28.78 | 0.8088 | 2.81 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 3 ReAn3 | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 29.67 | 28.64 | 29.67 | 29.33 | 0.5947 | 2.03 |
| | Stnd Conc (mg/L) | | 29.67 | 28.64 | 29.67 | 29.33 | 0.5947 | 2.03 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3g/L ReAn4 | BlnkCorr Signal | | 0.038 | 0.038 | 0.038 | 0.038 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 189.80 | 188.20 | 186.90 | 188.30 | 1.4526 | 0.77 |
| | Stnd Conc (mg/L) | | 189.80 | 188.20 | 186.90 | 188.30 | 1.4526 | 0.77 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 1 ReAn4 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 38.54 | 39.19 | 37.86 | 38.53 | 0.6651 | 1.73 |
| | Stnd Conc (mg/L) | | 38.54 | 39.19 | 37.86 | 38.53 | 0.6651 | 1.73 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 2 ReAn4 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 32.74 | 31.73 | 32.56 | 32.34 | 0.5387 | 1.67 |
| | Stnd Conc (mg/L) | | 32.74 | 31.73 | 32.56 | 32.34 | 0.5387 | 1.67 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 3 ReAn4 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 32.55 | 31.30 | 31.09 | 31.65 | 0.7893 | 2.49 |
| | Stnd Conc (mg/L) | | 32.55 | 31.30 | 31.09 | 31.65 | 0.7893 | 2.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 3g/L ReAn5 | BlnkCorr Signal | | 0.056 | 0.056 | 0.057 | 0.057 | 0.0006 | 1.01 |
| | sample conc (mg/L) | | 284.80 | 284.70 | 287.30 | 285.60 | 1.4731 | 0.52 |
| | Stnd Conc (mg/L) | | 284.80 | 284.70 | 287.30 | 285.60 | 1.4731 | 0.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 1 ReAn5 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 51.71 | 51.50 | 51.43 | 51.55 | 0.1457 | 0.28 |
| | Stnd Conc (mg/L) | | 51.71 | 51.50 | 51.43 | 51.55 | 0.1457 | 0.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 Wash 2 ReAn5 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 36.27 | 38.13 | 36.36 | 36.92 | 1.0489 | 2.84 |
| | Stnd Conc (mg/L) | | 36.27 | 38.13 | 36.36 | 36.92 | 1.0489 | 2.84 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 3 ReAn5 | BlnkCorr Signal | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 32.93 | 34.34 | 33.84 | 33.70 | 0.7149 | 2.12 |
| | Stnd Conc (mg/L) | 32.93 | 34.34 | 33.84 | 33.70 | 0.7149 | 2.12 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 3g/L ReAn6 | BlnkCorr Signal | 0.041 | 0.041 | 0.041 | 0.041 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 203.70 | 201.80 | 201.60 | 202.40 | 1.1590 | 0.57 |
| | Stnd Conc (mg/L) | 203.70 | 201.80 | 201.60 | 202.40 | 1.1590 | 0.57 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 1 ReAn6 | BlnkCorr Signal | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 46.89 | 47.31 | 48.96 | 47.72 | 1.0942 | 2.29 |
| | Stnd Conc (mg/L) | 46.89 | 47.31 | 48.96 | 47.72 | 1.0942 | 2.29 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 2 ReAn6 | BlnkCorr Signal | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 32.52 | 33.37 | 32.79 | 32.89 | 0.4343 | 1.32 |
| | Stnd Conc (mg/L) | 32.52 | 33.37 | 32.79 | 32.89 | 0.4343 | 1.32 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 Wash 3 ReAn6 | BlnkCorr Signal | 0.006 | 0.006 | 0.007 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | 30.29 | 29.53 | 30.77 | 30.20 | 0.6252 | 2.07 |
| | Stnd Conc (mg/L) | 30.29 | 29.53 | 30.77 | 30.20 | 0.6252 | 2.07 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 8M1 ReAn6 | BlnkCorr Signal | 0.027 | 0.027 | 0.028 | 0.027 | 0.0006 | 2.14 |
| | sample conc (mg/L) | 131.80 | 132.20 | 133.70 | 132.60 | 1.0017 | 0.76 |
| | Stnd Conc (mg/L) | 131.80 | 132.20 | 133.70 | 132.60 | 1.0017 | 0.76 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 8M2 ReAn6 | BlnkCorr Signal | 0.036 | 0.036 | 0.036 | 0.036 | 0.0000 | 0.00 |
| | sample conc (mg/L) | 176.10 | 176.00 | 174.50 | 175.50 | 0.8963 | 0.51 |
| | Stnd Conc (mg/L) | 176.10 | 176.00 | 174.50 | 175.50 | 0.8963 | 0.51 |

| Sample ID | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|
| Re T4 8M3 ReAn6 | BlnkCorr Signal | 0.024 | 0.025 | 0.024 | 0.024 | 0.0006 | 2.41 |
| | sample conc (mg/L) | 117.20 | 118.60 | 117.10 | 117.60 | 0.8386 | 0.71 |
| | Stnd Conc (mg/L) | 117.20 | 118.60 | 117.10 | 117.60 | 0.8386 | 0.71 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 84 ReAn6 | BlnkCorr Signal | | 0.020 | 0.020 | 0.020 | 0.020 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 94.20 | 94.51 | 95.93 | 94.88 | 0.9224 | 0.97 |
| | Stnd Conc (mg/L) | | 94.20 | 94.51 | 95.93 | 94.88 | 0.9224 | 0.97 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M5 ReAn6 | BlnkCorr Signal | | 0.018 | 0.017 | 0.018 | 0.018 | 0.0006 | 3.21 |
| | sample conc (mg/L) | | 83.69 | 83.19 | 83.52 | 83.47 | 0.2542 | 0.30 |
| | Stnd Conc (mg/L) | | 83.69 | 83.19 | 83.52 | 83.47 | 0.2542 | 0.30 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M6 ReAn6 | BlnkCorr Signal | | 0.014 | 0.013 | 0.013 | 0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | 64.20 | 62.36 | 61.54 | 62.70 | 1.3622 | 2.17 |
| | Stnd Conc (mg/L) | | 64.20 | 62.36 | 61.54 | 62.70 | 1.3622 | 2.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M7 ReAn6 | BlnkCorr Signal | | 0.010 | 0.011 | 0.011 | 0.011 | 0.0006 | 5.25 |
| | sample conc (mg/L) | | 49.39 | 51.86 | 49.84 | 50.36 | 1.3155 | 2.61 |
| | Stnd Conc (mg/L) | | 49.39 | 51.86 | 49.84 | 50.36 | 1.3155 | 2.61 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M8 ReAn6 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 43.77 | 43.99 | 43.93 | 43.90 | 0.1137 | 0.26 |
| | Stnd Conc (mg/L) | | 43.77 | 43.99 | 43.93 | 43.90 | 0.1137 | 0.26 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M9 ReAn6 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 39.51 | 37.58 | 38.69 | 38.59 | 0.9686 | 2.51 |
| | Stnd Conc (mg/L) | | 39.51 | 37.58 | 38.69 | 38.59 | 0.9686 | 2.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M10 ReAn6 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 35.05 | 34.01 | 33.40 | 34.15 | 0.8343 | 2.44 |
| | Stnd Conc (mg/L) | | 35.05 | 34.01 | 33.40 | 34.15 | 0.8343 | 2.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M11 ReAn6 | BlnkCorr Signal | | 0.007 | 0.007 | 0.006 | 0.006 | 0.0006 | 9.62 |
| | sample conc (mg/L) | | 30.41 | 30.39 | 29.55 | 30.12 | 0.4908 | 1.63 |
| | Stnd Conc (mg/L) | | 30.41 | 30.39 | 29.55 | 30.12 | 0.4908 | 1.63 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M12 ReAn6 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 35.83 | 36.81 | 35.97 | 36.20 | 0.5300 | 1.46 |
| | Stnd Conc (mg/L) | | 35.83 | 36.81 | 35.97 | 36.20 | 0.5300 | 1.46 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M13 ReAn6 | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 29.44 | 26.76 | 27.97 | 28.06 | 1.3421 | 4.78 |
| | Stnd Conc (mg/L) | | 29.44 | 26.76 | 27.97 | 28.06 | 1.3421 | 4.78 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M14 ReAn6 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 24.68 | 24.54 | 24.43 | 24.55 | 0.1253 | 0.51 |
| | Stnd Conc (mg/L) | | 24.68 | 24.54 | 24.43 | 24.55 | 0.1253 | 0.51 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M15 ReAn6 | BlnkCorr Signal | | 0.005 | 0.005 | 0.005 | 0.005 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 22.12 | 22.41 | 21.91 | 22.17 | 0.2512 | 1.13 |
| | Stnd Conc (mg/L) | | 22.12 | 22.41 | 21.91 | 22.17 | 0.2511 | 1.13 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T4 8M16 ReAn6 | BlnkCorr Signal | | 0.004 | 0.004 | 0.004 | 0.004 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 20.07 | 19.80 | 20.72 | 20.16 | 0.4729 | 2.35 |
| | Stnd Conc (mg/L) | | 20.07 | 19.80 | 20.72 | 20.16 | 0.4729 | 2.35 |

## XRF raw data - MIP Test 4

% to mg/L convertion

1% = 1g/100ml = 10g/1000ml = 10,000mg/1000ml = 10000mg/L

| ID | Element | XRF % | concentration (mg/L) |
|---|---|---|---|
| Before Rinse | Ta | 0.167 | 1670 |
| | Nb | 0.284 | 2840 |
| | Sn | 0.005 | 50 |
| | Ti | 0.552 | 5520 |
| | Fe | 0.051 | 510 |
| | Bal | 98.48 | 984800 |
| | Sb | 0.003 | 30 |
| | Mo | 0.044 | 440 |
| | Zr | 0.032 | 320 |

| | | | |
|---|---|---|---|
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.508** | **5080** |
| | V | 0.28 | 2800 |
| After Rinse | Ta | 0.093 | 930 |
| | Nb | 0.277 | 2770 |
| | Sn | 0.004 | 40 |
| | Ti | 0.5 | 5000 |
| | Bal | 98.78 | 987800 |
| | Sb | 0.002 | 20 |
| | Mo | 0.042 | 420 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.11** | **1100** |
| | V | 0.308 | 3080 |
| 1M1 | Ta | 0.11 | 1100 |
| | Nb | 0.25 | 2500 |
| | Ti | 0.425 | 4250 |
| | Bal | 98.87 | 988700 |
| | Mo | 0.037 | 370 |
| | Zr | 0.025 | 250 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.11** | **1100** |
| | V | 0.307 | 3070 |
| 1M2 | Ta | 0.107 | 1070 |
| | Nb | 0.278 | 2780 |
| | Sn | 0.005 | 50 |
| | Ti | 0.407 | 4070 |
| | Fe | 0.007 | 70 |
| | Bal | 98.85 | 988500 |
| | Sb | 0.005 | 50 |
| | Mo | 0.044 | 440 |
| | Zr | 0.028 | 280 |
| | Sr | 0.005 | 50 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.104** | **1040** |
| | V | 0.308 | 3080 |
| 1M3 | Ta | 0.106 | 1060 |
| | Nb | 0.272 | 2720 |
| | Sn | 0.003 | 30 |
| | Ti | 0.453 | 4530 |
| | Bal | 98.85 | 988500 |
| | Sb | 0.004 | 40 |

| | | | |
|---|---|---|---|
| | Mo | 0.041 | 410 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.093** | **930** |
| | V | 0.298 | 2980 |
| 1M4 | Ta | 0.108 | 1080 |
| | Nb | 0.27 | 2700 |
| | Sn | 0.004 | 40 |
| | Ti | 0.474 | 4740 |
| | Bal | 98.82 | 988200 |
| | Sb | 0.004 | 40 |
| | Mo | 0.043 | 430 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.101** | **1010** |
| | V | 0.285 | 2850 |
| 1M5 | Ta | 0.092 | 920 |
| | Nb | 0.286 | 2860 |
| | Sn | 0.005 | 50 |
| | Ti | 0.468 | 4680 |
| | Bal | 98.85 | 988500 |
| | Sb | 0.004 | 40 |
| | Mo | 0.046 | 460 |
| | Zr | 0.03 | 300 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.091** | **910** |
| | V | 0.273 | 2730 |
| 3M1 | Ta | 0.092 | 920 |
| | Nb | 0.264 | 2640 |
| | Sn | 0.003 | 30 |
| | Ti | 0.422 | 4220 |
| | Bal | 98.93 | 989300 |
| | Mo | 0.04 | 400 |
| | Zr | 0.026 | 260 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.07** | **700** |
| | V | 0.29 | 2900 |
| 3M2 | Ta | 0.101 | 1010 |
| | Nb | 0.209 | 2090 |
| | Sn | 0.003 | 30 |
| | Ti | 0.275 | 2750 |

| | | | |
|---|---|---|---|
| | Bal | 99.08 | 990800 |
| | Sb | 0.003 | 30 |
| | Mo | 0.03 | 300 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | **Re** | **0.127** | **1270** |
| | V | 0.266 | 2660 |
| 3M3 | Ta | 0.116 | 1160 |
| | Nb | 0.215 | 2150 |
| | Sn | 0.004 | 40 |
| | Ti | 0.228 | 2280 |
| | Bal | 99.04 | 990400 |
| | Sb | 0.004 | 40 |
| | Mo | 0.031 | 310 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.132** | **1320** |
| | V | 0.269 | 2690 |
| 3M4 | Ta | 0.108 | 1080 |
| | Nb | 0.219 | 2190 |
| | Sn | 0.004 | 40 |
| | Ti | 0.302 | 3020 |
| | Bal | 99.05 | 990500 |
| | Sb | 0.002 | 20 |
| | Mo | 0.032 | 320 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.129** | **1290** |
| | V | 0.254 | 2540 |
| 3M5 | Ta | 0.1 | 1000 |
| | Nb | 0.226 | 2260 |
| | Sn | 0.004 | 40 |
| | Ti | 0.283 | 2830 |
| | Bal | 99.06 | 990600 |
| | Sb | 0.004 | 40 |
| | Mo | 0.034 | 340 |
| | Zr | 0.023 | 230 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.134** | **1340** |
| | V | 0.247 | 2470 |
| 3M6 | Ta | 0.107 | 1070 |
| | Nb | 0.232 | 2320 |

| | | | |
|---|---|---|---|
| | Sn | 0.003 | 30 |
| | Ti | 0.331 | 3310 |
| | Bal | 98.98 | 989800 |
| | Sb | 0.004 | 40 |
| | Mo | 0.037 | 370 |
| | Zr | 0.024 | 240 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.123** | **1230** |
| | V | 0.274 | 2740 |
| 3M7 | Ta | 0.1 | 1000 |
| | Nb | 0.226 | 2260 |
| | Sn | 0.004 | 40 |
| | Ti | 0.315 | 3150 |
| | Bal | 99.02 | 990200 |
| | Sb | 0.002 | 20 |
| | Mo | 0.035 | 350 |
| | Zr | 0.022 | 220 |
| | Sr | 0.004 | 40 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.128** | **1280** |
| | V | 0.266 | 2660 |
| 3M8 | Ta | 0.097 | 970 |
| | Nb | 0.241 | 2410 |
| | Sn | 0.004 | 40 |
| | Ti | 0.332 | 3320 |
| | Bal | 98.97 | 989700 |
| | Sb | 0.004 | 40 |
| | Mo | 0.039 | 390 |
| | Zr | 0.025 | 250 |
| | Sr | 0.003 | 30 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.14** | **1400** |
| | V | 0.275 | 2750 |
| 6M1 | Ta | 0.113 | 1130 |
| | Nb | 0.207 | 2070 |
| | Ti | 0.338 | 3380 |
| | Bal | 99.05 | 990500 |
| | Sb | 0.003 | 30 |
| | Mo | 0.03 | 300 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.091** | **910** |
| | V | 0.261 | 2610 |

| | | | |
|---|---|---|---|
| 6M2 | Ta | 0.104 | 1040 |
| | Nb | 0.205 | 2050 |
| | Ti | 0.372 | 3720 |
| | Bal | 99.04 | 990400 |
| | Sb | 0.003 | 30 |
| | Mo | 0.027 | 270 |
| | Zr | 0.019 | 190 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.084** | **840** |
| | V | 0.285 | 2850 |
| 6M3 | Ta | 0.109 | 1090 |
| | Nb | 0.217 | 2170 |
| | Ti | 0.366 | 3660 |
| | Fe | 0.025 | 250 |
| | Bal | 98.98 | 989800 |
| | Sb | 0.004 | 40 |
| | Mo | 0.031 | 310 |
| | Zr | 0.021 | 210 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.089** | **890** |
| | V | 0.286 | 2860 |
| 6M4 | Ta | 0.082 | 820 |
| | Nb | 0.199 | 1990 |
| | Ti | 0.343 | 3430 |
| | Bal | 99.09 | 990900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.026 | 260 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.087** | **870** |
| | V | 0.257 | 2570 |
| 6M5 | Ta | 0.102 | 1020 |
| | Nb | 0.191 | 1910 |
| | Sn | 0.003 | 30 |
| | Ti | 0.351 | 3510 |
| | Bal | 99.1 | 991000 |
| | Mo | 0.022 | 220 |
| | Zr | 0.016 | 160 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.089** | **890** |
| | V | 0.236 | 2360 |

| | | | |
|---|---|---|---|
| 6M6 | Ta | 0.109 | 1090 |
| | Nb | 0.219 | 2190 |
| | Ti | 0.368 | 3680 |
| | Fe | 0.016 | 160 |
| | Bal | 98.99 | 989900 |
| | Sb | 0.003 | 30 |
| | Mo | 0.032 | 320 |
| | Zr | 0.022 | 220 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.08** | **800** |
| | V | 0.289 | 2890 |
| 6M7 | Ta | 0.084 | 840 |
| | Nb | 0.2 | 2000 |
| | Ti | 0.326 | 3260 |
| | Bal | 99.13 | 991300 |
| | Sb | 0.003 | 30 |
| | Mo | 0.027 | 270 |
| | Zr | 0.017 | 170 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.076** | **760** |
| | V | 0.246 | 2460 |
| 6M8 | Ta | 0.113 | 1130 |
| | Nb | 0.209 | 2090 |
| | Ti | 0.345 | 3450 |
| | Bal | 99.06 | 990600 |
| | Sb | 0.004 | 40 |
| | Mo | 0.029 | 290 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.077** | **770** |
| | V | 0.26 | 2600 |
| 8M1 | Ta | 0.092 | 920 |
| | Nb | 0.187 | 1870 |
| | Ti | 0.308 | 3080 |
| | Bal | 99.16 | 991600 |
| | Mo | 0.022 | 220 |
| | Zr | 0.016 | 160 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.064** | **640** |
| | V | 0.257 | 2570 |
| 8M2 | Ta | 0.091 | 910 |

| | | | |
|---|---|---|---|
| | Nb | 0.208 | 2080 |
| | Ti | 0.353 | 3530 |
| | Bal | 99.1 | 991000 |
| | Sb | 0.004 | 40 |
| | Mo | 0.029 | 290 |
| | Zr | 0.02 | 200 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.053** | **530** |
| | V | 0.234 | 2340 |
| 8M3 | Ta | 0.09 | 900 |
| | Nb | 0.194 | 1940 |
| | Sn | 0.003 | 30 |
| | Ti | 0.311 | 3110 |
| | Bal | 99.16 | 991600 |
| | Mo | 0.027 | 270 |
| | Zr | 0.018 | 180 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.056** | **560** |
| | V | 0.249 | 2490 |
| 8M4 | Ta | 0.088 | 880 |
| | Nb | 0.189 | 1890 |
| | Sn | 0.004 | 40 |
| | Ti | 0.318 | 3180 |
| | Bal | 99.12 | 991200 |
| | Mo | 0.027 | 270 |
| | Zr | 0.017 | 170 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.059** | **590** |
| | V | 0.274 | 2740 |
| 8M5 | Ta | 0.07 | 700 |
| | Nb | 0.178 | 1780 |
| | Sn | 0.003 | 30 |
| | Ti | 0.33 | 3300 |
| | Bal | 99.17 | 991700 |
| | Mo | 0.022 | 220 |
| | Zr | 0.015 | 150 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.061** | **610** |
| | V | 0.246 | 2460 |
| 8M6 | Ta | 0.074 | 740 |
| | Nb | 0.181 | 1810 |

| | | | |
|---|---|---|---|
| | Ti | 0.301 | 3010 |
| | Bal | 99.22 | 992200 |
| | Mo | 0.022 | 220 |
| | Zr | 0.015 | 150 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.043** | **430** |
| | V | 0.245 | 2450 |
| 8M7 | Ta | 0.064 | 640 |
| | Nb | 0.194 | 1940 |
| | Sn | 0.003 | 30 |
| | Ti | 0.315 | 3150 |
| | Bal | 99.21 | 992100 |
| | Sb | 0.003 | 30 |
| | Mo | 0.026 | 260 |
| | Zr | 0.017 | 170 |
| | Sr | 0.002 | 20 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.039** | **390** |
| | V | 0.226 | 2260 |
| 8M8 | Ta | 0.082 | 820 |
| | Nb | 0.199 | 1990 |
| | Sn | 0.003 | 30 |
| | Ti | 0.343 | 3430 |
| | Bal | 99.11 | 991100 |
| | Sb | 0.002 | 20 |
| | Mo | 0.027 | 270 |
| | Zr | 0.019 | 190 |
| | Sr | 0.003 | 30 |
| | Bi | 0.002 | 20 |
| | **Re** | **0.047** | **470** |
| | V | 0.27 | 2700 |
| 3000mg/L $NH_4ReO_4$ addition | Ta | 0.209 | 2090 |
| | Nb | 0.271 | 2710 |
| | Sn | 0.006 | 60 |
| | Ti | 0.334 | 3340 |
| | Bal | 98.72 | 987200 |
| | Sb | 0.004 | 40 |
| | Mo | 0.044 | 440 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.298** | **2980** |
| | V | 0.254 | 2540 |
| Wash 1 | Ta | 0.231 | 2310 |

| | | | |
|---|---|---|---|
| | Nb | 0.271 | 2710 |
| | Sn | 0.006 | 60 |
| | Ti | 0.3 | 3000 |
| | Bal | 98.7 | 987000 |
| | Sb | 0.004 | 40 |
| | Mo | 0.046 | 460 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.344** | **3440** |
| | V | 0.233 | 2330 |
| Wash 2 | Ta | 0.219 | 2190 |
| | Nb | 0.268 | 2680 |
| | Sn | 0.004 | 40 |
| | Ti | 0.307 | 3070 |
| | Bal | 98.68 | 986800 |
| | Mo | 0.043 | 430 |
| | Zr | 0.029 | 290 |
| | Sr | 0.004 | 40 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.344** | **3440** |
| | V | 0.266 | 2660 |
| Wash 3 | Ta | 0.2 | 2000 |
| | Nb | 0.276 | 2760 |
| | Sn | 0.004 | 40 |
| | Ti | 0.407 | 4070 |
| | Fe | 0.031 | 310 |
| | Bal | 98.63 | 986300 |
| | Mo | 0.045 | 450 |
| | Zr | 0.031 | 310 |
| | Sr | 0.004 | 40 |
| | Rb | 0.002 | 20 |
| | Bi | 0.003 | 30 |
| | **Re** | **0.26** | **2600** |
| | V | 0.293 | 2930 |
| 8M1 | Bal | 99.83 | 998300 |
| | Ta | 0.042 | 420 |
| | **Re** | **0.132** | **1320** |
| 8M2 | Bal | 99.83 | 998300 |
| | Ta | 0.046 | 460 |
| | **Re** | **0.125** | **1250** |
| 8M3 | Bal | 99.8 | 998000 |
| | Ta | 0.043 | 430 |
| | **Re** | **0.16** | **1600** |
| 8M4 | Bal | 99.82 | 998200 |

| | | | |
|---|---|---|---|
| | Ta | 0.047 | 470 |
| | **Re** | **0.137** | **1370** |
| 8M5 | Bal | 99.84 | 998400 |
| | Ta | 0.041 | 410 |
| | **Re** | **0.118** | **1180** |
| 8M6 | Bal | 99.85 | 998500 |
| | Ta | 0.042 | 420 |
| | **Re** | **0.105** | **1050** |
| 8M7 | Bal | 99.85 | 998500 |
| | Ta | 0.043 | 430 |
| | **Re** | **0.104** | **1040** |
| 8M8 | Bal | 99.86 | 998600 |
| | Ta | 0.032 | 320 |
| | **Re** | **0.111** | **1110** |
| 8M9 | Bal | 99.87 | 998700 |
| | Ta | 0.04 | 400 |
| | **Re** | **0.091** | **910** |
| 8M10 | Bal | 99.86 | 998600 |
| | Ta | 0.038 | 380 |
| | **Re** | **0.098** | **980** |
| 8M11 | Bal | 99.88 | 998800 |
| | Ta | 0.038 | 380 |
| | **Re** | **0.08** | **800** |
| 8M12 | Bal | 99.88 | 998800 |
| | Ta | 0.041 | 410 |
| | **Re** | **0.075** | **750** |
| 3000mg/L $NH_4ReO_4$ addition | Bal | 99.58 | 995800 |
| | Ta | 0.08 | 800 |
| | **Re** | **0.338** | **3380** |
| | Au | 0.002 | 20 |
| Wash 1 | Bal | 99.54 | 995400 |
| | As | 0.002 | 20 |
| | Ta | 0.079 | 790 |
| | **Re** | **0.373** | **3730** |
| | Au | 0.002 | 20 |
| Wash 2 | Bal | 99.57 | 995700 |
| | Ta | 0.08 | 800 |
| | **Re** | **0.347** | **3470** |
| | Au | 0.002 | 20 |
| Wash 3 | Bal | 99.54 | 995400 |
| | As | 0.002 | 20 |
| | Ta | 0.084 | 840 |
| | **Re** | **0.376** | **3760** |
| | Au | 0.002 | 20 |
| 3000mg/L | Bal | 99.22 | 992200 |

| | | | |
|---|---|---|---|
| $NH_4ReO_4$ addition (6000mg/L total) | As | 0.003 | 30 |
| | Ta | 0.122 | 1220 |
| | **Re** | **0.646** | **6460** |
| | Au | 0.005 | 50 |
| Wash 1 | Bal | 99.16 | 991600 |
| | As | 0.003 | 30 |
| | Ta | 0.127 | 1270 |
| | **Re** | **0.7** | **7000** |
| | Au | 0.005 | 50 |
| Wash 2 | Bal | 99.13 | 991300 |
| | As | 0.004 | 40 |
| | Ta | 0.132 | 1320 |
| | **Re** | **0.727** | **7270** |
| | Au | 0.004 | 40 |
| Wash 3 | Bal | 99.17 | 991700 |
| | As | 0.003 | 30 |
| | Ta | 0.126 | 1260 |
| | **Re** | **0.698** | **6980** |
| | Au | 0.004 | 40 |
| 3000mg/L $NH_4ReO_4$ addition (9000mg/L total) | Bal | 98.9 | 989000 |
| | As | 0.005 | 50 |
| | Ta | 0.148 | 1480 |
| | **Re** | **0.939** | **9390** |
| | Au | 0.007 | 70 |
| Wash 1 | Bal | 98.91 | 989100 |
| | As | 0.004 | 40 |
| | Ta | 0.13 | 1300 |
| | **Re** | **0.94** | **9400** |
| | Au | 0.006 | 60 |
| Wash 2 | Bal | 98.87 | 988700 |
| | As | 0.006 | 60 |
| | Ta | 0.146 | 1460 |
| | **Re** | **0.975** | **9750** |
| | Au | 0.006 | 60 |
| Wash 3 | Bal | 98.85 | 988500 |
| | As | 0.004 | 40 |
| | Ta | 0.149 | 1490 |
| | **Re** | **0.995** | **9950** |
| | Au | 0.006 | 60 |
| 3000mg/L $NH_4ReO_4$ addition (12000mg/L total) | Bal | 98.57 | 985700 |
| | As | 0.005 | 50 |
| | Ta | 0.155 | 1550 |
| | **Re** | **1.26** | **12600** |
| | Au | 0.008 | 80 |
| Wash 1 | Bal | 98.57 | 985700 |

| | | | |
|---|---|---|---|
| | As | 0.005 | 50 |
| | Ta | 0.165 | 1650 |
| | **Re** | **1.25** | **12500** |
| | Au | 0.009 | 90 |
| Wash 2 | Bal | 98.54 | 985400 |
| | As | 0.006 | 60 |
| | Ta | 0.157 | 1570 |
| | **Re** | **1.29** | **12900** |
| | Au | 0.008 | 80 |
| Wash 3 | Bal | 98.48 | 984800 |
| | As | 0.007 | 70 |
| | Ta | 0.169 | 1690 |
| | **Re** | **1.33** | **13300** |
| | Au | 0.009 | 90 |
| 3000mg/L $NH_4ReO_4$ addition (15000mg/L total) | Bal | 98.3 | 983000 |
| | As | 0.006 | 60 |
| | Ta | 0.181 | 1810 |
| | **Re** | **1.5** | **15000** |
| | Au | 0.009 | 90 |
| Wash 1 | Bal | 98.32 | 983200 |
| | As | 0.008 | 80 |
| | Ta | 0.181 | 1810 |
| | **Re** | **1.48** | **14800** |
| | Au | 0.01 | 100 |
| Wash 2 | Bal | 98.2 | 982000 |
| | As | 0.007 | 70 |
| | Ta | 0.192 | 1920 |
| | **Re** | **1.59** | **15900** |
| | Au | 0.01 | 100 |
| Wash 3 | Bal | 98.32 | 983200 |
| | As | 0.008 | 80 |
| | Ta | 0.18 | 1800 |
| | **Re** | **1.48** | **14800** |
| | Au | 0.009 | 90 |
| 3000mg/L $NH_4ReO_4$ addition (18000mg/L total) | Bal | 98.21 | 982100 |
| | As | 0.008 | 80 |
| | Ta | 0.193 | 1930 |
| | **Re** | **1.57** | **15700** |
| | Au | 0.01 | 100 |
| Wash 1 | Bal | 98.22 | 982200 |
| | As | 0.007 | 70 |
| | Ta | 0.177 | 1770 |
| | **Re** | **1.58** | **15800** |
| | Au | 0.008 | 80 |
| Wash 2 | Bal | 98.4 | 984000 |

| | | | |
|---|---|---|---|
| | As | 0.006 | 60 |
| | Ta | 0.147 | 1470 |
| | **Re** | **1.43** | **14300** |
| | Au | 0.008 | 80 |
| Wash 3 | Bal | 98.33 | 983300 |
| | As | 0.006 | 60 |
| | Ta | 0.183 | 1830 |
| | **Re** | **1.47** | **14700** |
| | Au | 0.007 | 70 |
| 8M1 A | Bal | 98.88 | 988800 |
| | As | 0.006 | 60 |
| | Ta | 0.167 | 1670 |
| | **Re** | **0.937** | **9370** |
| | Au | 0.01 | 100 |
| 8M2 A | Bal | 99.05 | 990500 |
| | As | 0.005 | 50 |
| | Ta | 0.143 | 1430 |
| | **Re** | **0.792** | **7920** |
| | Au | 0.008 | 80 |
| 8M3 A | Bal | 99.17 | 991700 |
| | As | 0.006 | 60 |
| | Ta | 0.127 | 1270 |
| | **Re** | **0.691** | **6910** |
| | Au | 0.007 | 70 |
| 8M4 A | Bal | 99.26 | 992600 |
| | As | 0.004 | 40 |
| | Ta | 0.122 | 1220 |
| | **Re** | **0.604** | **6040** |
| | Au | 0.005 | 50 |
| 8M5 A | Bal | 99.39 | 993900 |
| | As | 0.003 | 30 |
| | Ta | 0.099 | 990 |
| | **Re** | **0.503** | **5030** |
| | Au | 0.005 | 50 |
| 8M6 A | Bal | 99.44 | 994400 |
| | As | 0.003 | 30 |
| | Ta | 0.103 | 1030 |
| | **Re** | **0.445** | **4450** |
| | Au | 0.004 | 40 |
| 8M7 A | Bal | 99.54 | 995400 |
| | As | 0.002 | 20 |
| | Ta | 0.083 | 830 |
| | **Re** | **0.373** | **3730** |
| | Au | 0.003 | 30 |
| 8M8 A | Bal | 99.57 | 995700 |

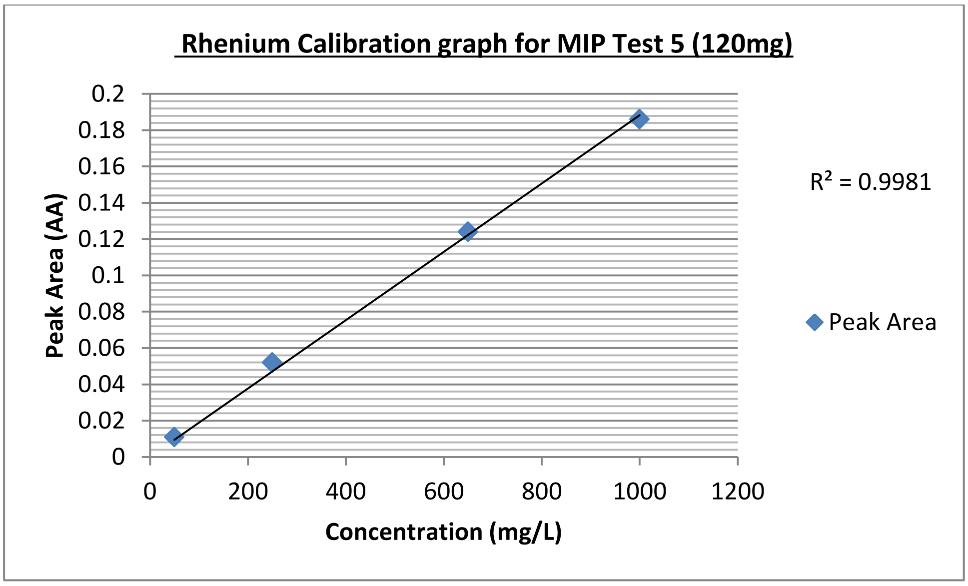
| | | | |
|---|---|---|---|
| | As | 0.002 | 20 |
| | Ta | 0.085 | 850 |
| | **Re** | **0.341** | **3410** |
| | Au | 0.003 | 30 |
| 8M9 A | Bal | 99.61 | 996100 |
| | As | 0.002 | 20 |
| | Ta | 0.076 | 760 |
| | **Re** | **0.312** | **3120** |
| | Au | 0.002 | 20 |
| 8M10 A | Bal | 99.66 | 996600 |
| | Ta | 0.066 | 660 |
| | **Re** | **0.268** | **2680** |
| | Au | 0.002 | 20 |
| 8M11 A | Bal | 99.68 | 996800 |
| | Ta | 0.065 | 650 |
| | **Re** | **0.25** | **2500** |
| | Au | 0.002 | 20 |
| 8M12 A | Bal | 99.73 | 997300 |
| | Ta | 0.056 | 560 |
| | **Re** | **0.207** | **2070** |
| 8M13 A | Bal | 99.75 | 997500 |
| | Ta | 0.058 | 580 |
| | **Re** | **0.188** | **1880** |
| 8M14 A | Bal | 99.79 | 997900 |
| | Ta | 0.046 | 460 |
| | **Re** | **0.161** | **1610** |
| 8M15 A | Bal | 99.81 | 998100 |
| | Ta | 0.045 | 450 |
| | **Re** | **0.149** | **1490** |
| 8M16 A | Bal | 99.81 | 998100 |
| | Ta | 0.044 | 440 |
| | **Re** | **0.142** | **1420** |

## 7.16. Appendix 16 - MIP Test 5 Calibration graph; XRF and AAS raw data

### Calibration graph data - MIP Test 5

range: 50 - 1000ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| | 0.608 | | | |
| blank | 0.608 | 0.608 | 0.00000 | 0.00 |
| | 0.608 | | | |
| | 0.011 | | | |
| 50 | 0.011 | 0.110 | 0.00000 | 0.00 |
| | 0.011 | | | |
| | 0.052 | | | |
| 250 | 0.052 | 0.052 | 0.00000 | 0.00 |
| | 0.052 | | | |
| | 0.124 | | | |
| 650 | 0.123 | 0.124 | 0.00058 | 0.47 |
| | 0.124 | | | |
| | 0.186 | | | |
| 1000 | 0.187 | 0.186 | 0.00153 | 0.82 |
| | 0.184 | | | |




### AAS raw data - MIP Test 5

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 A.R Template | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 43.82 | 43.36 | 43.24 | 43.47 | 0.3062 | 0.70 |
| | Stnd Conc (mg/L) | | 43.82 | 43.36 | 43.24 | 43.47 | 0.3062 | 0.70 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M1 Template | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 28.54 | 27.95 | 29.29 | 28.59 | 0.6716 | 2.35 |
| | Stnd Conc (mg/L) | | 28.54 | 27.95 | 29.29 | 28.59 | 0.6716 | 2.35 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M2 Template | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 27.18 | 28.68 | 26.83 | 27.56 | 0.9828 | 3.57 |
| | Stnd Conc (mg/L) | | 27.18 | 28.68 | 26.83 | 27.56 | 0.9828 | 3.57 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M3 Template | BlnkCorr Signal | | 0.006 | 0.006 | 0.006 | 0.006 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 28.08 | 29.30 | 28.65 | 28.68 | 0.6104 | 2.13 |
| | Stnd Conc (mg/L) | | 28.08 | 29.30 | 28.65 | 28.68 | 0.6104 | 2.13 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M4 Template | BlnkCorr Signal | | 0.007 | 0.006 | 0.007 | 0.007 | 0.0006 | 8.25 |
| | sample conc (mg/L) | | 30.95 | 28.63 | 30.73 | 30.10 | 1.2807 | 4.25 |
| | Stnd Conc (mg/L) | | 30.95 | 28.63 | 30.73 | 30.10 | 1.2807 | 4.25 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M5 Template | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 31.39 | 31.92 | 31.02 | 31.44 | 0.4524 | 1.44 |
| | Stnd Conc (mg/L) | | 31.39 | 31.92 | 31.02 | 31.44 | 0.4524 | 1.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M6 Template | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 32.07 | 32.65 | 34.31 | 33.01 | 1.1626 | 3.52 |
| | Stnd Conc (mg/L) | | 32.07 | 32.65 | 34.31 | 33.01 | 1.1626 | 3.52 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 3g/L ReAn1 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 31.06 | 32.72 | 33.92 | 32.57 | 1.4362 | 4.41 |
| | Stnd Conc (mg/L) | | 31.06 | 32.72 | 33.92 | 32.57 | 1.4362 | 4.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 1 ReAn1 | BlnkCorr Signal | | 0.007 | 0.007 | 0.007 | 0.007 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 32.72 | 33.82 | 34.29 | 33.61 | 0.8058 | 2.40 |
| | Stnd Conc (mg/L) | | 32.72 | 33.82 | 34.29 | 33.61 | 0.8058 | 2.40 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 2 ReAn1 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 36.61 | 35.10 | 36.64 | 36.12 | 0.8806 | 2.44 |
| | Stnd Conc (mg/L) | | 36.61 | 35.10 | 36.64 | 36.12 | 0.8806 | 2.44 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 3 ReAn1 | BlnkCorr Signal | | 0.008 | 0.008 | 0.008 | 0.008 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 37.85 | 37.68 | 38.91 | 38.15 | 0.6665 | 1.75 |
| | Stnd Conc (mg/L) | | 37.85 | 37.68 | 38.91 | 38.15 | 0.6665 | 1.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 3g/L ReAn2 | BlnkCorr Signal | | 0.008 | 0.009 | 0.009 | 0.009 | 0.0006 | 6.42 |
| | sample conc (mg/L) | | 39.19 | 40.20 | 41.28 | 40.22 | 1.0452 | 2.60 |
| | Stnd Conc (mg/L) | | 39.19 | 40.20 | 41.28 | 40.22 | 1.0452 | 2.60 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 1 ReAn2 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 41.18 | 42.26 | 42.26 | 41.90 | 0.6235 | 1.49 |
| | Stnd Conc (mg/L) | | 41.18 | 42.26 | 42.26 | 41.90 | 0.6235 | 1.49 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 2 ReAn2 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 42.88 | 43.09 | 43.97 | 43.31 | 0.5783 | 1.34 |
| | Stnd Conc (mg/L) | | 42.88 | 43.09 | 43.97 | 43.31 | 0.5783 | 1.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 3 ReAn2 | BlnkCorr Signal | | 0.009 | 0.009 | 0.010 | 0.010 | 0.0006 | 5.77 |
| | sample conc (mg/L) | | 43.20 | 43.92 | 45.17 | 44.10 | 0.9968 | 2.26 |
| | Stnd Conc (mg/L) | | 43.20 | 43.92 | 45.17 | 44.10 | 0.9968 | 2.26 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 3g/L ReAn3 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 54.58 | 54.67 | 55.33 | 54.86 | 0.4095 | 0.75 |
| | Stnd Conc (mg/L) | | 54.58 | 54.67 | 55.33 | 54.86 | 0.4095 | 0.75 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 1 ReAn3 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 46.62 | 46.89 | 47.22 | 46.91 | 0.3005 | 0.64 |
| | Stnd Conc (mg/L) | | 46.62 | 46.89 | 47.22 | 46.91 | 0.3005 | 0.64 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 2 ReAn3 | BlnkCorr Signal | | 0.010 | 0.010 | 0.010 | 0.010 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 46.63 | 48.60 | 46.62 | 47.28 | 1.1403 | 2.41 |
| | Stnd Conc (mg/L) | | 46.63 | 48.60 | 46.62 | 47.28 | 1.1403 | 2.41 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 3 ReAn3 | BlnkCorr Signal | | 0.011 | 0.011 | 0.011 | 0.011 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 49.59 | 50.27 | 49.24 | 49.70 | 0.5237 | 1.05 |
| | Stnd Conc (mg/L) | | 49.59 | 50.27 | 49.24 | 49.70 | 0.5237 | 1.05 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 3g/L ReAn4 | BlnkCorr Signal | | 0.068 | 0.067 | 0.068 | 0.068 | 0.0006 | 0.85 |
| | sample conc (mg/L) | | 334.70 | 332.60 | 333.70 | 333.70 | 1.0504 | 0.31 |
| | Stnd Conc (mg/L) | | 334.70 | 332.60 | 333.70 | 333.70 | 1.0504 | 0.31 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 1 ReAn4 | BlnkCorr Signal | | 0.013 | 0.013 | 0.013 | 0.013 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 62.82 | 61.86 | 62.87 | 62.52 | 0.5692 | 0.91 |
| | Stnd Conc (mg/L) | | 62.82 | 61.86 | 62.87 | 62.52 | 0.5692 | 0.91 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 2 ReAn4 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 55.28 | 53.60 | 55.08 | 54.65 | 0.9177 | 1.68 |
| | Stnd Conc (mg/L) | | 55.28 | 53.60 | 55.08 | 54.65 | 0.9177 | 1.68 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 3 ReAn4 | BlnkCorr Signal | | 0.012 | 0.012 | 0.012 | 0.012 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 56.67 | 56.53 | 56.26 | 56.49 | 0.2084 | 0.37 |
| | Stnd Conc (mg/L) | | 56.67 | 56.53 | 56.26 | 56.49 | 0.2084 | 0.37 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 3g/L ReAn5 | BlnkCorr Signal | | 0.084 | 0.084 | 0.084 | 0.084 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 421.70 | 422.60 | 419.80 | 421.40 | 1.4295 | 0.34 |
| | Stnd Conc (mg/L) | | 421.70 | 422.60 | 419.80 | 421.40 | 1.4295 | 0.34 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 1 ReAn5 | BlnkCorr Signal | | 0.024 | 0.023 | 0.022 | 0.023 | 0.0010 | 4.35 |
| | sample conc (mg/L) | | 111.20 | 110.40 | 103.60 | 108.40 | 4.1761 | 3.85 |
| | Stnd Conc (mg/L) | | 111.20 | 110.40 | 103.60 | 108.40 | 4.1761 | 3.85 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 2 ReAn5 | BlnkCorr Signal | | 0.013 | 0.014 | 0.013 | 0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | 61.49 | 63.38 | 62.74 | 62.54 | 0.9613 | 1.54 |
| | Stnd Conc (mg/L) | | 61.49 | 63.38 | 62.74 | 62.54 | 0.9613 | 1.54 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 3 ReAn5 | BlnkCorr Signal | | 0.013 | 0.013 | 0.014 | 0.013 | 0.0006 | 4.44 |
| | sample conc (mg/L) | | 61.96 | 62.50 | 63.39 | 62.62 | 0.7221 | 1.15 |
| | Stnd Conc (mg/L) | | 61.96 | 62.50 | 63.39 | 62.62 | 0.7221 | 1.15 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 3g/L ReAn6 | BlnkCorr Signal | | 0.091 | 0.091 | 0.090 | 0.091 | 0.0006 | 0.63 |
| | sample conc (mg/L) | | 461.10 | 457.10 | 456.40 | 458.20 | 2.5357 | 0.55 |
| | Stnd Conc (mg/L) | | 461.10 | 457.10 | 456.40 | 458.20 | 2.5357 | 0.55 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 1 ReAn6 | BlnkCorr Signal | | 0.026 | 0.026 | 0.026 | 0.026 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 124.00 | 123.30 | 123.60 | 123.60 | 0.3512 | 0.28 |
| | Stnd Conc (mg/L) | | 124.00 | 123.30 | 123.60 | 123.60 | 0.3512 | 0.28 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 2 ReAn6 | BlnkCorr Signal | | 0.016 | 0.016 | 0.016 | 0.016 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 73.92 | 74.97 | 75.92 | 74.94 | 1.0004 | 1.33 |
| | Stnd Conc (mg/L) | | 73.92 | 74.97 | 75.92 | 74.94 | 1.0004 | 1.33 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 Wash 3 ReAn6 | BlnkCorr Signal | | 0.017 | 0.017 | 0.018 | 0.017 | 0.0006 | 3.40 |
| | sample conc (mg/L) | | 78.43 | 81.21 | 83.43 | 81.02 | 2.5052 | 3.09 |
| | Stnd Conc (mg/L) | | 78.43 | 81.21 | 83.43 | 81.02 | 2.5052 | 3.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M1 ReAn6 | BlnkCorr Signal | | 0.034 | 0.035 | 0.036 | 0.035 | 0.0010 | 2.86 |
| | sample conc (mg/L) | | 164.10 | 166.90 | 173.50 | 168.10 | 4.8263 | 2.87 |
| | Stnd Conc (mg/L) | | 164.10 | 166.90 | 173.50 | 168.10 | 4.8263 | 2.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M2 ReAn6 | BlnkCorr Signal | | 0.038 | 0.038 | 0.039 | 0.039 | 0.0006 | 1.48 |
| | sample conc (mg/L) | | 181.50 | 184.10 | 189.10 | 184.90 | 3.8626 | 2.09 |
| | Stnd Conc (mg/L) | | 181.50 | 184.10 | 189.10 | 184.90 | 3.8626 | 2.09 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M3 ReAn6 | BlnkCorr Signal | | 0.037 | 0.037 | 0.037 | 0.037 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 176.70 | 176.70 | 177.90 | 177.10 | 0.6928 | 0.39 |
| | Stnd Conc (mg/L) | | 176.70 | 176.70 | 177.90 | 177.10 | 0.6928 | 0.39 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T5 8M4 ReAn6 | BlnkCorr Signal | | 0.036 | 0.038 | 0.038 | 0.038 | 0.0012 | 3.04 |
| | sample conc (mg/L) | | 174.60 | 181.00 | 183.50 | 179.70 | 4.5902 | 2.55 |
| | Stnd Conc (mg/L) | | 174.60 | 181.00 | 183.50 | 179.70 | 4.5902 | 2.55 |

## XRF raw data - MIP Test 5

| ID | Element | XRF % | concentration (mg/L) | Average (mg/L) |
|---|---|---|---|---|
| Before Rinse | Bal | 99.42 | 994200 | 994100 |
| | | 99.4 | 994000 | |
| | As | 0.002 | 20 | 25 |
| | | 0.003 | 30 | |
| | Ta | 0.094 | 940 | 960 |
| | | 0.098 | 980 | |
| | **Re** | **0.476** | **4760** | **4830** |
| | | **0.49** | **4900** | |
| | Au | 0.005 | 50 | 45 |
| | | 0.004 | 40 | |
| After Rinse | Bal | 99.81 | 998100 | 998100 |
| | | 99.81 | 998100 | |
| | Ta | 0.042 | 420 | 410 |
| | | 0.04 | 400 | |
| | **Re** | **0.148** | **1480** | **1480** |
| | | **0.148** | **1480** | |
| 8M1 | Bal | 99.87 | 998700 | 998700 |
| | | 99.87 | 998700 | |
| | Ta | 0.041 | 410 | 410 |
| | | 0.041 | 410 | |
| | **Re** | **0.087** | **870** | **880** |
| | | **0.089** | **890** | |
| 8M2 | Bal | 99.89 | 998900 | - |
| | Ta | 0.035 | 350 | - |
| | **Re** | **0.072** | **720** | - |
| 8M3 | Bal | 99.9 | 999000 | - |
| | Ta | 0.034 | 340 | - |
| | **Re** | **0.07** | **700** | - |
| 8M4 | Bal | 99.9 | 999000 | - |
| | Ta | 0.037 | 370 | - |
| | **Re** | **0.064** | **640** | - |

| | | | | |
|---|---|---|---|---|
| 8M5 | Bal | 99.91 | 999100 | - |
| | Ta | 0.032 | 320 | - |
| | **Re** | **0.059** | **590** | - |
| 8M6 | Bal | 99.91 | 999100 | - |
| | Ta | 0.036 | 360 | - |
| | **Re** | **0.057** | **570** | - |
| 3000mg/L $NH_4ReO_4$ analyte addition | Bal | 98.76 | 987600 | 988000 |
| | | 98.84 | 988400 | |
| | As | 0.004 | 40 | 35 |
| | | 0.003 | 30 | |
| | Ta | 0.114 | 1140 | 1010 |
| | | 0.088 | 880 | |
| | **Re** | **1.12** | **11200** | **10950** |
| | | **1.07** | **10700** | |
| | Au | 0.005 | 50 | 325 |
| | | 0.06 | 600 | |
| Wash 1 | Bal | 98.74 | 987400 | - |
| | As | 0.03 | 300 | - |
| | Ta | 0.114 | 1140 | - |
| | **Re** | **1.13** | **11300** | - |
| | Au | 0.007 | 70 | - |
| Wash 2 | Bal | 98.94 | 989400 | - |
| | As | 0.003 | 30 | - |
| | Ta | 0.087 | 870 | - |
| | **Re** | **0.963** | **9630** | - |
| | Au | 0.006 | 60 | - |
| Wash 3 | Bal | 98.94 | 989400 | - |
| | As | 0.003 | 30 | - |
| | Ta | 0.086 | 860 | - |
| | **Re** | **0.961** | **9610** | - |
| | Au | 0.006 | 60 | - |
| 3000mg/L $NH_4ReO_4$ analyte addition (6000mg/L Total) | Bal | 98.55 | 985500 | - |
| | As | 0.005 | 50 | - |
| | Ta | 0.116 | 1160 | - |
| | **Re** | **1.32** | **13200** | - |
| | Au | 0.008 | 80 | - |
| Wash 1 | Bal | 98.35 | 983500 | - |
| | As | 0.006 | 60 | - |
| | Ta | 0.145 | 1450 | - |
| | **Re** | **1.49** | **14900** | - |
| | Au | 0.009 | 90 | - |
| Wash 2 | Bal | 98.44 | 984400 | - |
| | As | 0.005 | 50 | - |
| | Ta | 0.132 | 1320 | - |

| | | | | |
|---|---|---|---|---|
| | **Re** | **1.41** | **14100** | - |
| | Au | 0.008 | 80 | - |
| Wash 3 | Bal | 98.5 | 985000 | - |
| | As | 0.006 | 60 | - |
| | Ta | 0.115 | 1150 | - |
| | **Re** | **1.37** | **13700** | - |
| | Au | 0.008 | 80 | - |
| 3000mg/L $NH_4ReO_4$ analyte addition (9000mg/L Total) | Bal | 98.15 | 981500 | - |
| | As | 0.006 | 60 | - |
| | Ta | 0.134 | 1340 | - |
| | **Re** | **1.66** | **16600** | - |
| | Au | 0.011 | 110 | - |
| Wash 1 | Bal | 98.03 | 980300 | - |
| | As | 0.008 | 80 | - |
| | Ta | 0.178 | 1780 | - |
| | **Re** | **1.77** | **17700** | - |
| | Au | 0.011 | 110 | - |
| Wash 2 | Bal | 98.17 | 981700 | - |
| | As | 0.007 | 70 | - |
| | Ta | 0.163 | 1630 | - |
| | **Re** | **1.65** | **16500** | - |
| | Au | 0.01 | 100 | - |
| Wash 3 | Bal | 98.19 | 981900 | - |
| | As | 0.007 | 70 | - |
| | Ta | 0.148 | 1480 | - |
| | **Re** | **1.64** | **16400** | - |
| | Au | 0.01 | 100 | - |
| 3000mg/L $NH_4ReO_4$ analyte addition (12000mg/L Total) | Bal | 98.01 | 980100 | - |
| | As | 0.007 | 70 | - |
| | Ta | 0.173 | 1730 | - |
| | **Re** | **1.79** | **17900** | - |
| | Au | 0.012 | 120 | - |
| Wash 1 | Bal | 97.88 | 978800 | - |
| | As | 0.009 | 90 | - |
| | Ta | 0.195 | 1950 | - |
| | **Re** | **1.9** | **19000** | - |
| | Au | 0.013 | 130 | - |
| Wash 2 | Bal | 97.87 | 978700 | - |
| | As | 0.007 | 70 | - |
| | Ta | 0.188 | 1880 | - |
| | **Re** | **1.93** | **19300** | - |
| | Au | 0.012 | 120 | - |

| | | | | |
|---|---|---|---|---|
| Wash 3 | Bal | 98.11 | 981100 | - |
| | As | 0.006 | 60 | - |
| | Ta | 0.168 | 1680 | - |
| | **Re** | **1.71** | **17100** | - |
| | Au | 0.01 | 100 | - |
| 3000mg/L $NH_4ReO_4$ analyte addition (15000mg/L Total) | Bal | 97.73 | 977300 | - |
| | As | 0.008 | 80 | - |
| | Ta | 0.227 | 2270 | - |
| | **Re** | **2.02** | **20200** | - |
| | Au | 0.012 | 120 | - |
| Wash 1 | Bal | 97.89 | 978900 | - |
| | As | 0.009 | 90 | - |
| | Ta | 0.199 | 1990 | - |
| | **Re** | **1.89** | **18900** | - |
| | Au | 0.012 | 120 | - |
| Wash 2 | Bal | 97.94 | 979400 | - |
| | As | 0.007 | 70 | - |
| | Ta | 0.193 | 1930 | - |
| | **Re** | **1.84** | **18400** | - |
| | Au | 0.012 | 120 | - |
| Wash3 | Bal | 97.91 | 979100 | - |
| | As | 0.008 | 80 | - |
| | Ta | 0.197 | 1970 | - |
| | **Re** | **1.87** | **18700** | - |
| | Au | 0.011 | 110 | - |
| 3000mg/L $NH_4ReO_4$ analyte addition (18000mg/L Total) | Bal | 97.95 | 979500 | 979200 |
| | | 97.89 | 978900 | |
| | As | 0.009 | 90 | 85 |
| | | 0.008 | 80 | |
| | Ta | 0.192 | 1920 | 1985 |
| | | 0.205 | 2050 | |
| | **Re** | **1.82** | **18200** | **18500** |
| | | **1.88** | **18800** | |
| | Au | 0.011 | 110 | 115 |
| | | 0.012 | 120 | |
| Wash 1 | Bal | 97.85 | 978500 | - |
| | As | 0.011 | 110 | - |
| | Ta | 0.228 | 2280 | - |
| | **Re** | **1.9** | **19000** | - |
| | Au | 0.012 | 120 | - |
| Wash 2 | Bal | 97.97 | 979700 | - |
| | As | 0.009 | 90 | - |
| | Ta | 0.205 | 2050 | - |
| | **Re** | **1.8** | **18000** | - |

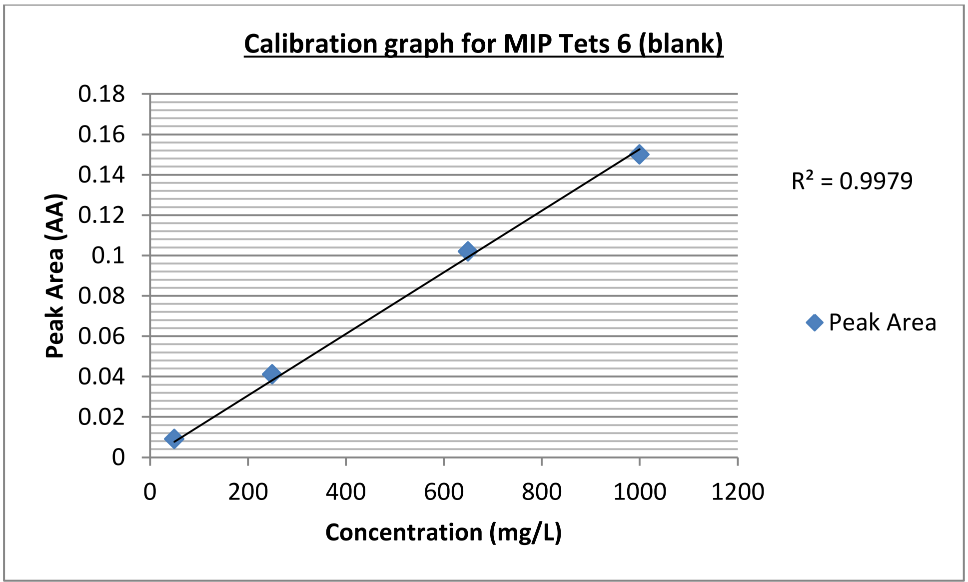
| | | | | |
|---|---|---|---|---|
| | Au | 0.012 | 120 | - |
| Wash3 | Bal | 97.99 | 979900 | - |
| | As | 0.009 | 90 | - |
| | Ta | 0.199 | 1990 | - |
| | **Re** | **1.79** | **17900** | - |
| | Au | 0.01 | 100 | - |
| 8M1 | Bal | 98.69 | 986900 | 987950 |
| | | 98.9 | 989000 | |
| | As | 0.008 | 80 | 75 |
| | | 0.007 | 70 | |
| | Ta | 0.183 | 1830 | 1745 |
| | | 0.166 | 1660 | |
| | **Re** | **1.11** | **11100** | **10650** |
| | | **1.02** | **10200** | |
| | Au | 0.01 | 100 | 95 |
| | | 0.009 | 90 | |
| 8M2 | Bal | 98.87 | 988700 | - |
| | As | 0.007 | 70 | - |
| | Ta | 0.169 | 1690 | - |
| | **Re** | **0.948** | **9480** | - |
| | Au | 0.009 | 90 | - |
| 8M3 | Bal | 98.94 | 989400 | - |
| | As | 0.006 | 60 | - |
| | Ta | 0.166 | 1660 | - |
| | **Re** | **0.877** | **8770** | - |
| | Au | 0.008 | 80 | - |
| 8M4 | Bal | 99.13 | 991300 | - |
| | As | 0.004 | 40 | - |
| | Ta | 0.126 | 1260 | - |
| | **Re** | **0.728** | **7280** | - |
| | Au | 0.007 | 70 | - |

### 7.17. Appendix 17 - MIP Test 6 (blank) Calibration graph; XRF and AAS raw data

**Calibration data - MIP Test 6**

range: 50 - 1000ppm (mg/L)

| Concentration (ppm) | BlnkCorr (AA) | Average | SD | RSD% |
|---|---|---|---|---|
| blank | 0.486 | 0.486 | 0.00000 | 0.00 |
| | 0.486 | | | |
| | 0.486 | | | |
| 50 | 0.008 | 0.009 | 0.00058 | 6.42 |
| | 0.008 | | | |
| | 0.009 | | | |
| 250 | 0.041 | 0.041 | 0.00000 | 0.00 |
| | 0.041 | | | |
| | 0.041 | | | |
| 650 | 0.101 | 0.102 | 0.00058 | 0.57 |
| | 0.102 | | | |
| | 0.102 | | | |
| 1000 | 0.157 | 0.150 | 0.01012 | 6.74 |
| | 0.156 | | | |
| | 0.139 | | | |




**AAS raw data - MIP Test 6**

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T6 Wash 1 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 52.56 | 53.68 | 54.19 | 53.48 | 0.8338 | 1.56 |
| | Stnd Conc (mg/L) | | 52.56 | 53.68 | 54.19 | 53.48 | 0.8338 | 1.56 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T6 Wash 2 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 53.05 | 53.98 | 53.48 | 53.50 | 0.4654 | 0.87 |
| | Stnd Conc (mg/L) | | 53.05 | 53.98 | 53.48 | 53.50 | 0.4654 | 0.87 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T6 Wash 3 | BlnkCorr Signal | | 0.009 | 0.009 | 0.009 | 0.009 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 53.58 | 54.48 | 53.25 | 53.77 | 0.6366 | 1.18 |
| | Stnd Conc (mg/L) | | 53.58 | 54.48 | 53.25 | 53.77 | 0.6366 | 1.18 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T6 3g/L ReAn1 | BlnkCorr Signal | | 0.059 | 0.060 | 0.058 | 0.059 | 0.0010 | 1.69 |
| | sample conc (mg/L) | | 366.90 | 368.80 | 360.60 | 365.40 | 4.2922 | 1.17 |
| | Stnd Conc (mg/L) | | 366.90 | 368.80 | 360.60 | 365.40 | 4.2922 | 1.17 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T6 Wash 1 ReAn1 | BlnkCorr Signal | | 0.025 | 0.025 | 0.025 | 0.025 | 0.0000 | 0.00 |
| | sample conc (mg/L) | | 149.90 | 149.40 | 148.30 | 149.20 | 0.8185 | 0.55 |
| | Stnd Conc (mg/L) | | 149.90 | 149.40 | 149.30 | 149.20 | 0.3215 | 0.22 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T6 Wash 2 ReAn1 | BlnkCorr Signal | | 0.024 | 0.025 | 0.025 | 0.025 | 0.0006 | 2.31 |
| | sample conc (mg/L) | | 147.50 | 148.60 | 148.20 | 148.10 | 0.5568 | 0.38 |
| | Stnd Conc (mg/L) | | 147.50 | 148.60 | 148.20 | 148.10 | 0.5568 | 0.38 |

| Sample ID | | | run 1 | run 2 | run 3 | Average | SD | RSD % |
|---|---|---|---|---|---|---|---|---|
| Re T6 Wash 3 ReAn1 | BlnkCorr Signal | | 0.026 | 0.026 | 0.025 | 0.026 | 0.0006 | 2.22 |
| | sample conc (mg/L) | | 151.20 | 149.30 | 148.90 | 149.80 | 1.2288 | 0.82 |
| | Stnd Conc (mg/L) | | 151.20 | 149.30 | 148.90 | 149.80 | 1.2288 | 0.82 |

**XRF raw data - MIP Test 6**

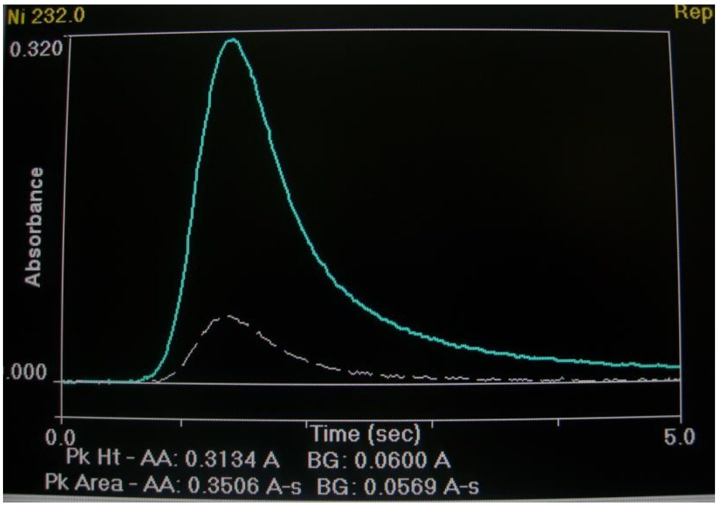
| ID | Element | XRF % | concentration (mg/L) | Average (mg/L) |
|---|---|---|---|---|
| Before Rinse | Bal | 99.97 | 999700 | 999700.00 |
| | | 99.97 | 999700 | |
| | | 99.97 | 999700 | |
| | Ta | 0.029 | 290 | 286.67 |
| | | 0.03 | 300 | |
| | | 0.027 | 270 | |
| Rinse 1 | Bal | 99.98 | 999800 | 999800.00 |
| | | 99.98 | 999800 | |

| | | | | |
|---|---|---|---|---|
| | | 99.98 | 999800 | |
| | Ta | 0.022 | 220 | 213.33 |
| | | 0.018 | 180 | |
| | | 0.024 | 240 | |
| Rinse 2 | Bal | 99.98 | 999800 | 999800.00 |
| | | 99.98 | 999800 | |
| | | 99.98 | 999800 | |
| | Ta | 0.019 | 190 | 186.67 |
| | | 0.019 | 190 | |
| | | 0.018 | 180 | |
| Rinse 3 | Bal | 99.98 | 999800 | 999800.00 |
| | | 99.98 | 999800 | |
| | | 99.98 | 999800 | |
| | Ta | 0.019 | 190 | 186.67 |
| | | 0.017 | 170 | |
| | | 0.02 | 200 | |
| 3000mg/L $NH_4ReO_4$ analyte addition | Bal | 99.77 | 997700 | 997366.67 |
| | | 99.73 | 997300 | |
| | | 99.71 | 997100 | |
| | Ta | 0.044 | 440 | 523.33 |
| | | 0.055 | 550 | |
| | | 0.058 | 580 | |
| | **Re** | **0.184** | **1840** | **2083.33** |
| | | **0.215** | **2150** | |
| | | **0.226** | **2260** | |
| Wash 1 | Bal | 99.93 | 999300 | 999166.67 |
| | | 99.91 | 999100 | |
| | | 99.91 | 999100 | |
| | Ta | 0.025 | 250 | 266.67 |
| | | 0.026 | 260 | |
| | | 0.029 | 290 | |
| | **Re** | **0.046** | **460** | **550.00** |
| | | **0.06** | **600** | |
| | | **0.059** | **590** | |
| Wash 2 | Bal | 99.95 | 999500 | 999466.67 |
| | | 99.94 | 999400 | |
| | | 99.95 | 999500 | |
| | Ta | 0.027 | 270 | 273.33 |
| | | 0.027 | 270 | |
| | | 0.028 | 280 | |
| | **Re** | **0.028** | **280** | **276.67** |
| | | **0.029** | **290** | |
| | | **0.026** | **260** | |
| Wash 3 | Bal | 99.95 | 999500 | 999500.00 |
| | | 99.95 | 999500 | |

| | | | | |
|---|---|---|---|---|
| | | 99.95 | 999500 | |
| | Ta | 0.03 | 300 | 286.67 |
| | | 0.028 | 280 | |
| | | 0.028 | 280 | |
| | **Re** | **0.02** | **200** | **206.67** |
| | | **0.019** | **190** | |
| | | **0.023** | **230** | |

## 7.18. Appendix 18 - Comparison between a normal looking peak and one which is too concentrated (furnace AAS)

- 'Normal' looking peak where concentration is within range




- Peak is too concentrated and 'roll over' is occuring